POWER

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The Open Mind

I says, "How do you know you're right?"
"How do I know?" says he.
"Well now I vum, I know by Gum;
I'm right because I be."

YOU all know him, the Village Oracle of whom Joe Lincoln writes in "Cape Cod Ballads." He is "sot." He has his own opinions and expresses them freely. His mind is made up and the door is shut. He does not want to hear anything different.

And they do not live only in the villages or among the unlettered. There is neither speech nor language where their voice is not heard.

Men believe, or think they know, in crowds. A little propaganda, a stirring of popular prejudice, an appeal to ingrained sentiment or animosity, the shaking of a well concocted Bugaboo, and they are off like a flock of crows after their leader or of sheep before the driving collie.

Somebody has said, "To have some intelligent appreciation of how much of the knowable is yet unknown conduces to that humility which is the beginning of wisdom."

Pride argues, humility is willing to discuss.

Self-interest disputes and haggles for advantage. Fairness approaches a subject with an open mind in an honest effort to find the truth.

One does not have to go outside of engineering and related subjects to find examples of this type of mind.

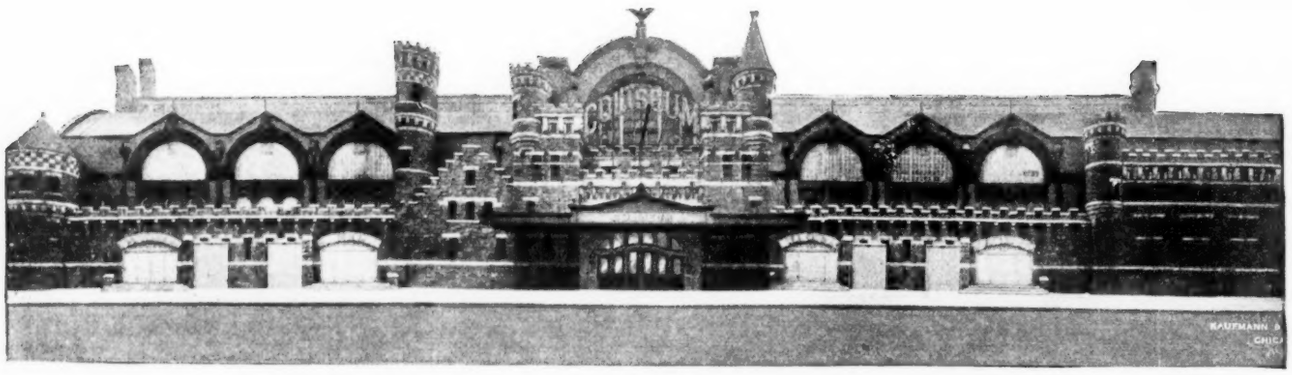
We can all think of men who are conspicuous within their limited circles by knowing things that are not so and being beyond any possibility of conviction otherwise.

Turn a question over to them in which their particular slant is involved and, whatever the conditions, their conclusions may be safely predicted.

This does not mean that they are purchasable or venal. They are made that way by their environment and training, perhaps by generalization from a particular experience, perhaps by the impressment of the views of those to whom they look up and whom they serve. They are right because they *be* and because it is good for them to be so.

They are obstacles in the way of Truth. They impede progress and prolong the existence of false ideals and wasteful practices.

The spread of literacy, increasing leisure and the printing press are making their ridiculousness apparent to all except themselves and, let us hope, limiting the increase of their tribe.



The Coliseum, where the Power Conference and Show will be held

The Midwest Power Conference and Chicago Power Show

By THOMAS WILSON
Western Editor of *Power*

WHEN the first power conference of the Middle West and the Chicago Power Show were inaugurated a year ago, some doubts were expressed as to the advisability of the latter in view of an enterprise of the same character—the New York Power Show—having been already well established. It was felt by many that expositions of mechanical equipment in connection with national and even local gatherings of engineers were becoming too numerous and, owing to the frequency of these exhibitions, there was little opportunity for much development of apparatus during the intervening intervals; hence a repetition of exhibits was inevitable together with a probable duplication in the audience.

However, an analysis of the attendance at the two shows indicated little duplication. Over 94 per cent of those visiting the Chicago Show came from the five Central States of Illinois, Indiana, Michigan, Ohio and Wisconsin, whereas 93½ per cent of those at the New York Show came from the Eastern States of New York, Pennsylvania, New Jersey, Massachusetts and Connecticut. This, viewed in connection with an attendance of 50,000 and 175 exhibitors at the Chicago Show, convinced its sponsors as to the correctness of their initial premise and led to the conception of producing annually a Chicago show. This would give engineers in the power field an opportunity of viewing progress in that field through the medium of two great annual exhibitions, one in each of the two great industrial centers of the country.

As a verification of the desirability of an annual Chicago Power Show, the 175 exhibitors of a year ago have increased to 260 this year and in 350 booths will fully occupy the 82,000 sq.ft. of floor space in the Coliseum.

It is claimed that there are more power-generating stations within a 500-mile area around Chicago than in any other section of the country of similar size. In the immediate Chicago region a per capita use of electricity of 1,050 kw.-hr. per year is greater than that of any other city. The central district contains the greatest transmission interconnection system under one interest of any place in the world. The largest generating station in the country, housing units of the greatest capacity on record, is in the making.

With these facts it is clear that in a broad sense the Middle West has taken front rank in the important developments and uses of power and that an annual review and display of developments is most fitting in this section.

A preliminary inspection of the list of exhibitors and the products to be on display has made it clear that the second annual Chicago Power Show will constitute an index of the scope and influence of the power industry. The show will bring out new developments in boilers, turbines, engines and motors, and the latest construction in powdered-coal equipment of all types, air preheaters, water-cooled furnace walls, stokers and draft apparatus. Water softening and filtering, means of transporting coal and ash, valves of all types for the higher pressures and temperatures, combustion control, regulators and many other power-plant specialties will be on display, and new features in auxiliaries, complete lines of heating and ventilating specialties, instruments and attractive exhibits of electrical equipment will be shown. In fact, the exposition in its entirety will give an excellent idea of the present status of the art and a complete résumé of progress and development.

It is most fitting and timely that the power show should be held during the same week and in the same building as the Midwest Power Conference, as the combination affords the visiting engineer the double opportunity of seeing and hearing about late develop-

S. A. Taylor

Program of Midwest Power Conference

Chicago

February 15-18

Coliseum

1513 So. Wabash Ave.

Chairman—W. S. MONROE

S. G. Neiler

Tuesday, February 15

12:00 noon—Registration.

2:30 p.m.—"The Middle West and the Power Conference," by W. S. Monroe, president of Sargent & Lundy, Chicago. "Increasing Value of Power to Home and Industry," by W. W. Freeman, president of the Union Gas & Electric Co., Cincinnati.

Wednesday, February 16

10:00 a.m.—"The Use of Power in Steel Mills," by W. Sykes, consulting steel mill engineer, Chicago. "The Use of Power in the Food Industry," by J. J. Merrill, chief engineer, Corn Products Refining Company. "The Use of Power in Paper Mills," by V. D. Simons, consulting engineer, Chicago.

2.00 p.m.—"The Cement Mill as a Food and Power Producer," by J. H. Lendi, chief electrical engineer, Universal Portland Cement Co. "Industrial Power Plant Developments," by S. G. Neiler, of Neiler, Rich & Co., consulting engineers, Chicago. "The Use of Power in the Packing Industry," by C. H. Kane, manager construction department, Swift & Co., Chicago.

Thursday, February 17

10:00 a.m.—"Economies of Coordinating Gas and Electric Power Supply," by Samuel Insull, Jr., president of the Midland Utilities Co. "Recent Electrical Development," by Paul Clapp, managing director of the National Electric Light Association, New York City.

1:30 p.m.—Inspection trips by bus to the Calumet Station of the Commonwealth Edison Company and to the main works of the Crane Company, 4100 S. Kedzie Ave.

7:30 p.m.—Annual banquet in the Grand Ball Room of the Palmer House. Speaker of the evening, Samuel Insull, Sr.

Friday, February 18

10:00 a.m.—"Location of and Coal for Central Power Plants," by Samuel A. Taylor, president of the American Institute of Mining and Metallurgical Engineers, Pittsburgh; "Recent Developments in Coal Burning," by F. S. Collings, mechanical engineer, Sargent & Lundy, Chicago; "Fuel Oil Supply from the Middle West," by Campbell Osborn, economist of Marland Oil Company, Ponca City, Okla.

1:30 p.m.—Inspection trips by bus to the South Chicago works of the Illinois Steel Company and to the new plant of the Chicago By-Products Coke Company, at 35th St. and Crawford Ave.

V. D. Simons

C. H. Kane

ments in the field. Sponsored by the local adherents of six engineering societies, the Conference is a notable example of co-operative effort. The organizations interested are the regional sections of the American Society of Mechanical Engineers, American Institute of Electrical Engineers, National Electric Light Association, American Institute of Mining and Metallurgical Engineers, National Safety Council and the big local engineering body, the Western Society of Engineers. The executive officers heading a general conference committee of two members from each of the foregoing societies are: William S. Monroe, president of Sargent & Lundy, chairman; George E. Pfisterer, secretary, and C. C. Whittier, of Robert W. Hunt Co., treasurer.

As indicated in the accompanying program of the Conference the essence of progressive thought and work on the manifold problems of the power industry will be compressed into four days of interesting discussion. Opening on Tuesday afternoon, Feb. 15, there will be in all five technical sessions, two afternoons devoted to inspection trips to plants pertinent to the discussions and a banquet in the Grand Ball Room and the Red Lacquer Room of the Palmer House, which is to be the outstanding event of the Conference. Samuel Insull will be the speaker of the evening. Reports from the intensive preliminary work that is being done indicate an exceptionally large attendance.

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Samuel Insull, Sr.

At the conference last year the speakers in the main devoted themselves to the special power problems relative to the trends in practice toward getting better economy, better use of equipment and wider availability of power. While the necessary phases of these problems may be touched upon in this year's conference, it has been agreed that in the main the broader aspects of the power problem should be presented, owing in part to the large number of engineering societies participating and the diversification of their interests.

Primarily, the conference will be devoted to the general subject of utilization of power in industry, with special reference to industry as a whole as well as to the various subdivisions such as steel and paper mills and the food, cement and packing industries. Other papers will deal with the economies of co-ordinating gas and electric power supply, recent developments in the electrical field and in coal burning, new features in industrial power plants and the location of central power plants with reference to the coal supply.

From the outline of the program presented it will be seen that the authors are at or near the top of their respective fields, the topics are diversified and with the numbers of papers per session limited, giving time for ample discussion, those who attend will be assured an unusual opportunity to broaden their grasp on the various phases of the power problem in different fields.

For those interested in local plants, inspection tours have been arranged for the afternoons of Thursday and Friday. On Thursday one of the trips will be to the Calumet Station of the Commonwealth Edison Company, a modern forced-draft chain-grate plant having an aggregate capacity of 187,000 kw. in six units. Features will be the new powdered-coal test installation, including economizer, air preheater and various late developments, and in connection with the big 24-ft. wide stokers, the introduction over the fire of part of the combustion air. Booster fans and Venturi type nozzles are employed to give sufficient velocity to insure thorough mixing with the gases, with the result that the elimination of smoke is accompanied by an improvement in combustion.

An alternate inspection trip is to the works of the Crane Company. Here visitors will be interested in the electric-furnace steel foundry, where castings of valves and fittings for all pressures and purposes are made, and in one of the most complete and modern brass shops in the country, where castings are made while in transit on a conveyor belt.

On Friday afternoon visitors will have an opportunity of visiting the plant of the Illinois Steel Co., where steel is produced by the open-hearth bessemer and electric methods. The works has eleven modern blast furnaces and modern electric-driven mills for the rolling of structural shapes and sheared and universal plate. Perhaps of more direct interest is the modern gas-engine power plant containing six of the largest gas engines in the country, and the vertical fire-tube waste-heat boilers that have been developed at this plant.

At the new plant of the Chicago By-Products Coke Company, also on the list for Friday afternoon, visitors will see a coal-gas plant having 105 Koppers ovens together with the coal and coke handling equipment and complete byproduct and gas purification plants. Per day it has capacity to carburet 2,000 tons of coal and produce 25,000,000 cu.ft. of gas.

Chicago has played a great part in the Middle West and, by virtue of its position, will continue to take an ever-increasing share of activity in the progressive development of this great industrial section. Attendance at the conference will indicate the interest that is being taken in this annual event, its value to the engineers of the surrounding territory and the desirability of continuing the effort. Last year registration exceeded 1,200, and to the coming conference expectations reach well up toward a total attendance of 2,000.

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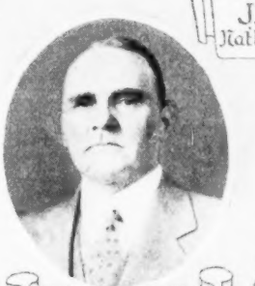

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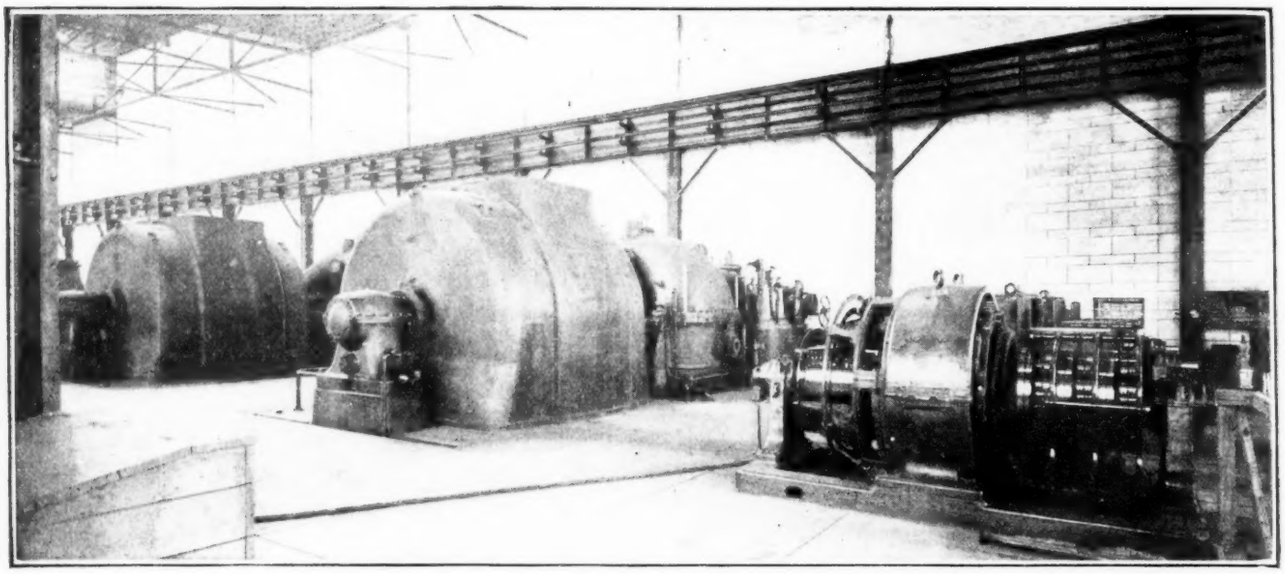


Turbine-generators and rotary converters

Latest Practice Found in New Power and Blowing Plant of Inland Steel Company

By WILFRED SYKES
Assistant to General Superintendent, Inland Steel Company

MODERN condensing turbine-generator and turbine-blower plant supplied from boilers burning blast-furnace gas supplemented in part by oil. The boilers are operated six months at a time without shutdown. Power is generated per kilowatt-hour for less than 20,000 B.t.u. in gas.

THE Inland Steel Company, Indiana Harbor, Ind., has built recently a new power and blowing engine house at its blast furnaces which utilizes blast-furnace gas for generating steam used for blowing the furnaces and for supplying power to the steel mills. This power house illustrates the modern trend of development in the steel industry for utilization of blast furnace gas in an economical manner and embodies a number of features that have not been adopted generally for industrial power houses in the past.

For generating power there are three 12,500-kva. Westinghouse turbine-generators operating at 270 to 300 lb. and 200 deg. of superheat. These units deliver three-phase 25-cycle current at 2,400 volts. From the turbines the steam exhausts into two-pass surface condensers, each having 15,000 sq.ft. of surface, or 1.2 sq.ft. per kva.

Duplicate motor-driven condensate pumps are provided for handling the condensed steam, the condensate passing first through the condensers of the air ejectors serving the main condensers, and then to the main feed tank. Each condensate pump is large enough to handle the full capacity of the turbine, and either may be used as desired. Air is removed from the condensers by duplicate two-stage air ejectors, either of which is large enough to take care of the machine under normal conditions. The turbine-generators are supported on structural-steel foundations arranged also to carry the condensers. These structural steel supports for the turbines are carried on a reinforced-concrete slab of such dimensions as to limit the load to approximately 1,500 lb. per sq.ft. The foundation rests on sand, without piling.

For the generators a closed air-cooling system has been provided, which consists of suitable inlet and outlet ducts with an air cooler made up of sprays and a water eliminator. As the same air is continually circulated, there is no trouble from dirt accumulating in the windings, and the danger of fires is reduced materially owing to the small amount of air in the system.

Adjacent to the turbine-generators are four 1,000-kw. 250-volt rotary converters on the same floor as the generators, and the transformers are in the basement immediately below. The power from these converters is used for the operation of auxiliary equipment in the neighborhood of this station and is distributed through a direct-current switchboard located above the main cell structure.

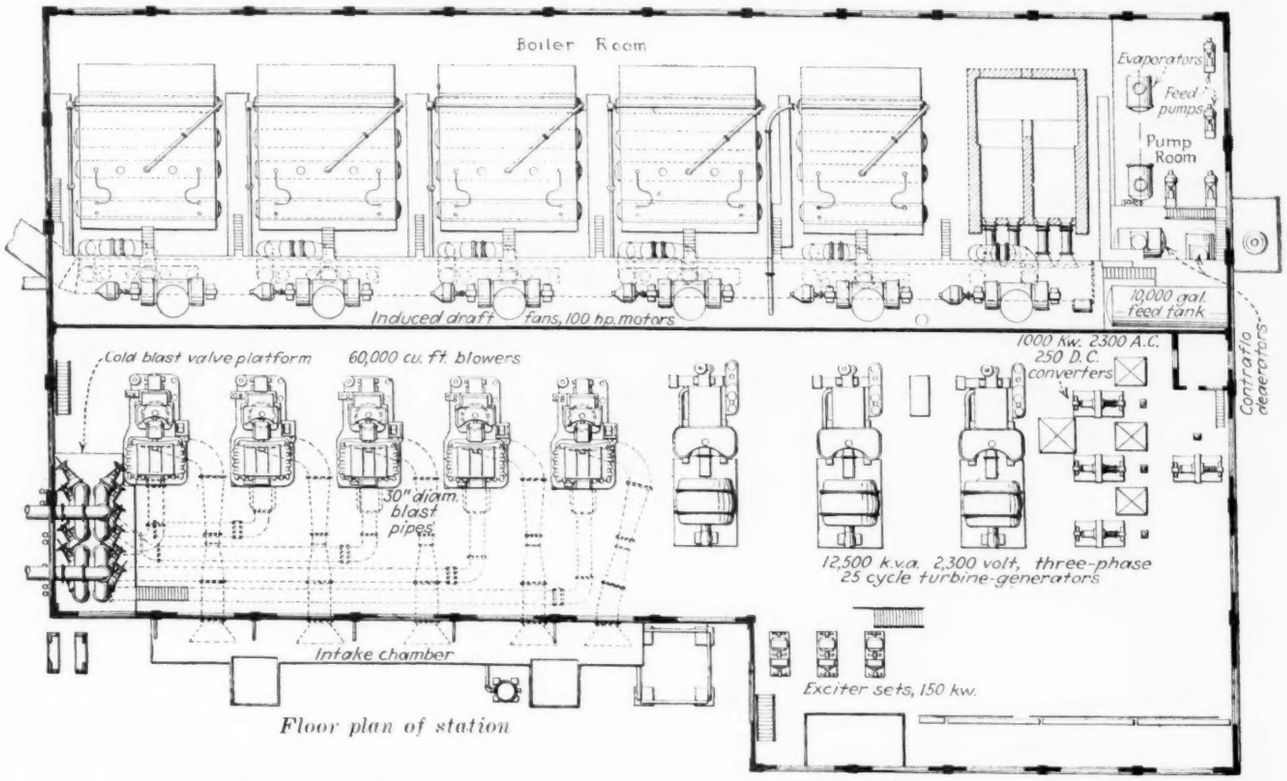
On the same floor as the turbine-generators there are five Ingersoll-Rand turbine-blowers, each having a capacity of 60,000 cu.ft. of air per minute against a

pressure of 30 lb. per sq.in. At full capacity the turbines driving these blowers develop approximately 7,000 hp. The steam from the turbine-blowers is condensed in individual surface condensers, arranged with divided water boxes. These condensers are provided with duplicate motor-driven condensate pumps and duplicate two-stage air ejectors.

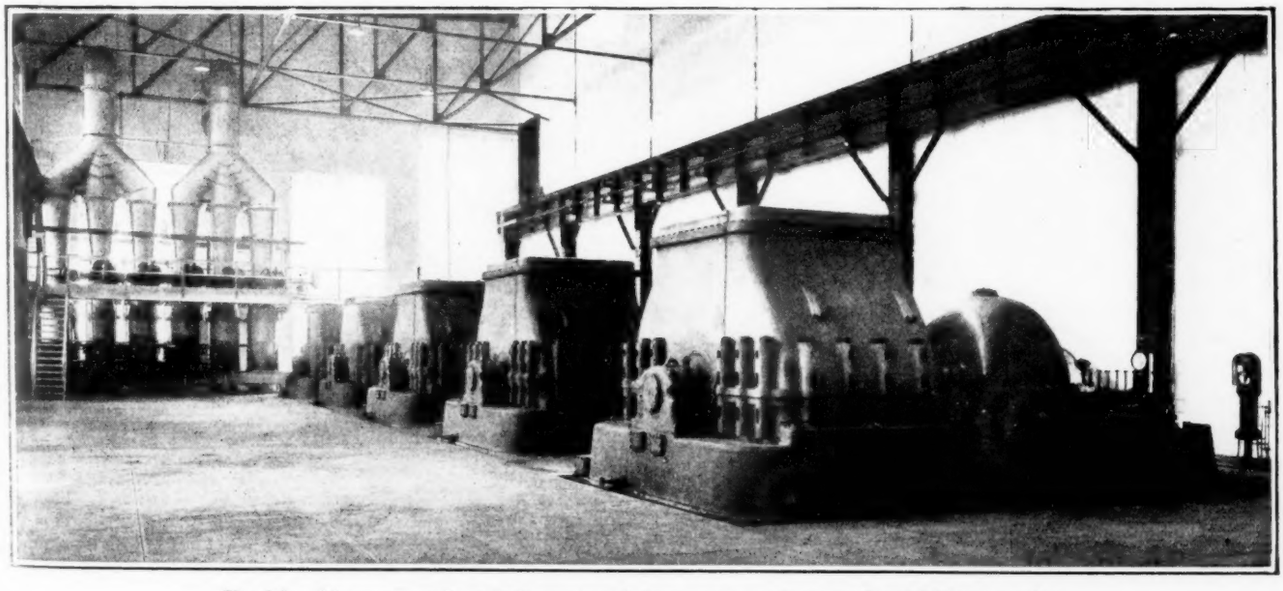
At the end of the power house there are piping connections so arranged that the blowers can be used on different blast furnaces, these connections being made by motor-driven gate valves controlled from a board located centrally in relation to the blowers.

When the blast furnaces are being cast, it is necessary to reduce the volume and pressure of the air blown, and this can be done by hand from a valve located at the blower or the valve can be operated by a motor from the control board. Four blowers are in use at a time, the fifth machine being a spare for all four furnaces.

Condensing water is supplied from a pumphouse on the lake front, in which there are three motor-driven centrifugal pumps, each having a capacity of 35,000,000 gal. a day against a total head of 30 ft. Provision is made for the installation of three additional pumps at some future date. The water is carried from this pumphouse a distance of about 1,200 ft. through a 60-in. cast-iron line from which branches are connected with the individual condensers through suitable gate valves. The amount of water passing to each condenser is regulated by these valves and depends upon the inlet temperature and the load being carried. The turbine-blower con-



Floor plan of station



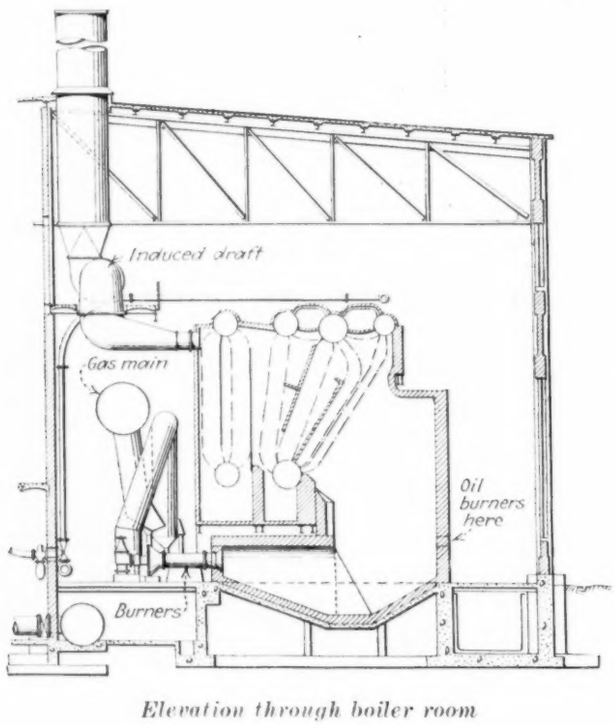
Turbine-blowers and at left motor-driven gate valves and cold-blast mains

densers with divided water boxes have two connections to the main circulating water header so either side of the condenser can be cut out independently.

Discharge water from the condensers flows to a trench that has a sump at one end and an outlet into a sewer at the other. Above the sump are three pumps having a capacity of 30,000,000 gal. a day against a head of 120 ft., which are used for supplying service water to the plant. At the other end of the trench there is a discharge weir that allows any excess water to flow back to the lake.

In the boiler house located parallel to the turbine room are four 15,000-sq.ft. and two 12,000-sq.ft. boilers of the Heine "V" type with integral economizers, the economizer surface being about 60 per cent of the boiler surface. Above the boilers is a platform on which are the induced-draft fans. Each boiler is provided with an individual fan that discharges into a short steel stack immediately above it. These fans are driven by direct-current motors, the speed of which is controlled by an automatic regulator that maintains a constant pressure in the combustion chamber independent of the variation in the amount of gas burned.

The gas supply for the boilers is brought into the boiler room in a 90-in. main, which connects through a

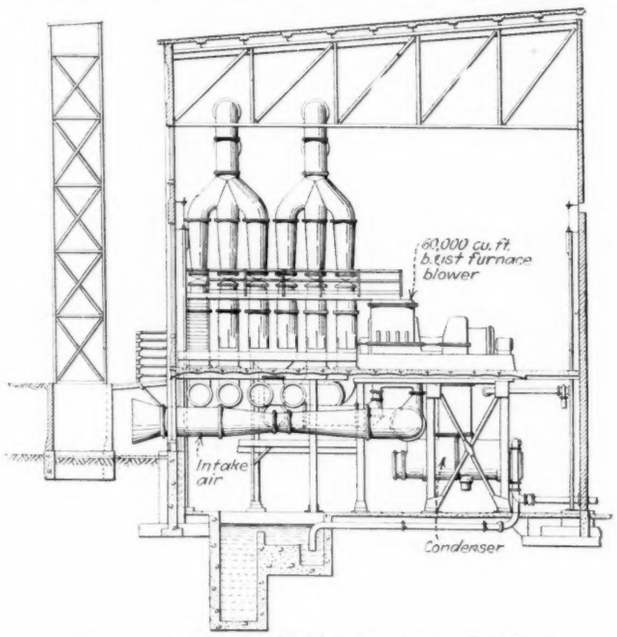


Elevation through boiler room

water seal to a gas box in front of each boiler. On each box there are four valves for controlling the gas to the four burners.

Feed water is supplied by turbine-driven centrifugal pumps. The water passes from the feed tank into which it is discharged by the condensate pumps through a Griscom-Russell deaërating heater and then into the feed pumps. The flow to the individual boilers is controlled by duplicate Copes regulators. Exhaust steam from these pumping units is used for preheating the boiler feed.

No raw water enters the boilers, and all the feed water is deaërated, so that the oxygen content is reduced to approximately 0.05 c.c. per liter. To make up for unavoidable leaks and losses, Griscom-Russell two-stage evaporators are provided. These evaporators are fed with lake water that is first heated in an open heater. The steam for the evaporators is taken from the main steam line and, after it condenses, is discharged through drainers to a flash tank that returns this water to the main feed tank. The vapor from the



Arrangement of cold blast mains and valves

raw-water discharges into the main exhaust line and is condensed together with the steam from the boiler-feed turbines in the deaërating heater. This condensate is returned directly to the deaërating heater.

Operating results have been most satisfactory. The first turbine-generator and two 12,000-sq.ft. boilers were put into operation in July, 1924. The turbine-blowers and remaining turbine-generators have only recently been installed.

Owing to the system used for burning gas and the use of distilled water only in the boilers, maintenance of the boilers has been practically negligible. After running continuously for six months without shutdown, they are taken off the line, inspected by the insurance company, and any minor repairs necessary made to the brickwork. There have been no repairs on the boilers or superheaters to date, nor are there any signs of pitting or corrosion. All the brickwork repairs have been of a minor nature, and it is usual to have the boiler back on the line within three or four days from the time it is shut down, most of this time being taken for cooling sufficiently to allow for inspection. The boilers are run usually between 160 and 200 per cent of normal rating, depending upon the load and the gas available, although when there is sufficient gas they can be operated as high as 250 per cent of rating on blast-furnace gas alone.

In addition to blast-furnace gas, oil burners are provided on four of the boilers to assist when there is a gas shortage.

During week days the electrical load on the station varies from about 20,000 to 30,000 kw., being controlled by the demand from the mills and the amount of gas available. In normal operation the power station will generate a kilowatt-hour with less than 20,000 B.t.u. in gas.

Smoke Abatement in St. Louis

By WILLIAM G. CHRISTY*

Comprehensive Campaign Being Carried on by Citizens' Smoke Abatement League. Average Soot Fall for December Found To Be Over 900 Tons per Square Mile. Education and Co-operation the Keynote

IN THE SPRING of 1926, the Citizens Smoke Abatement League of St. Louis was organized through the efforts of the Public Affairs Committee of the St. Louis Section of the American Society of Mechanical Engineers, in co-operation with the Women's Smoke Abatement League, the Associated Engineering Societies of St. Louis and the Smoke Committee of the Chamber of Commerce. It is a civic organization, composed of delegates from some fifty civic, professional and social organizations, and financed by public subscription, which is putting on the most comprehensive campaign ever attempted in St. Louis for reduction of the smoke nuisance which has been prevalent there so long.

The League has seven officers including an executive secretary who devotes his entire time to the work. It has retained a consulting engineer, Osborn Monnett, who has made a national reputation in smoke-abatement work and for a number of years has been a consulting engineer for the United States Bureau of mines. The work is divided into six divisions, with many prominent St. Louisans serving as chairmen and members of committees. Under the direct supervision of Mr. Monnett the Survey Division is making a smoke survey of the St. Louis metropolitan district, as such a survey eliminates the guesswork as to who is making the smoke.

EXPERIENCE in other campaigns has shown that no amount of education and equipment will reduce the smoke unless the matter is followed up. A striking illustration has been furnished during the last year when supervision was withdrawn in Salt Lake City and in a period of two months the smoke conditions went back four years, notwithstanding the fact that every furnace of any size was properly equipped and the man instructed in methods of firing that preclude smoke.

It is natural to think that the other fellow is the worst offender. For instance, a prominent business man in St. Louis made the statement that the railroads were making from 60 to 75 per cent of the smoke in St. Louis and the first thing to do in the campaign was to electrify the railroads. As a matter of fact, judging from conditions in other cities, the railroads probably make about 18 to 20 per cent of the smoke. The railroads of St. Louis are better organized in smoke work than any other industry, and it is estimated they have reduced their smoke 30 to 40 per cent in the last two years.

A part of this survey is a study of meteorological conditions. The local Weather Bureau is co-operating closely in this work through a study of the atmospheric conditions such as wind direction, wind velocity, fogs, humidity, barometric pressure and various other phenomena.

A series of Ringelman chart readings is now being made, covering the following classes of smokers: Railroads, brickyards, industrial plants, large heating plants and domestic heating plants. These readings are scheduled to cover all hours of the day and also different periods of the year. When this work is finished, reliable hourly smoke density will be available for all the classes of smokers under consideration. In connection with this a fuel survey of the district is being made. Statistics are now being compiled showing the amount and character of fuel used in the metropolitan district. The total tonnage of fuel is being traced and divided up among the various classes of fuel users previously mentioned. When this work has been completed, it will be possible to tell definitely the smoke density of each class of smoker and also the proportion of the total smoke made by each class.

Another part of the survey work is a soot-fall study. Nineteen standard locations have been selected in the city and suburbs. Standard jars have been placed on the roofs of buildings at the locations selected, for the collection of precipitates from the atmosphere. This work was started on Nov. 1, and on Dec. 1 the jars were collected and the material dried, weighed and ignited so that the weight of combustible material could be obtained. This is calculated in terms of precipitation of soot in tons per square mile per annum, as is the case in similar surveys, so that the results can be compared with those in other cities and also with results in future studies in St. Louis. During November the soot fall varied from 77 to 2,880 tons per square mile per annum in the various locations. The average was 775 tons. The average for December was 909 tons per square mile.

The League is also planning to divide the city into some eight districts and have an instructor working in each. He will observe the bad smokers and will follow them up by endeavoring to get the janitors or firemen to attend the Furnace Firing School. The instructor will be a practical man who will actually fire the furnace or boilers if necessary.

A short time ago this patrol work was tried out in a small district. A block was selected where everyone burned soft coal and the buildings consisted of residences and two-family apartments. A point of observation was established and the smoke densities obtained without knowledge of the householders. An expert instructor then went from door to door offering free firing instructions and asking co-operation in the smoke abate-

*Executive secretary, Citizens' Smoke Abatement League.

ment campaign. About 5 per cent of the residents refused to have anything to do with the man and another 5 per cent gave practically no co-operation. The other 90 per cent co-operated fully. After three days the smoke densities were again observed and it was found that smoke from the residences had been reduced 50 per cent and from the apartment buildings 40 per cent, or an average of 45 per cent. Leaving out the bad smokers who refused to co-operate, the smoke reduction from the residences was 71 per cent. The final readings were taken while the residents of the block were doing their own firing. This work is now being started in other districts.

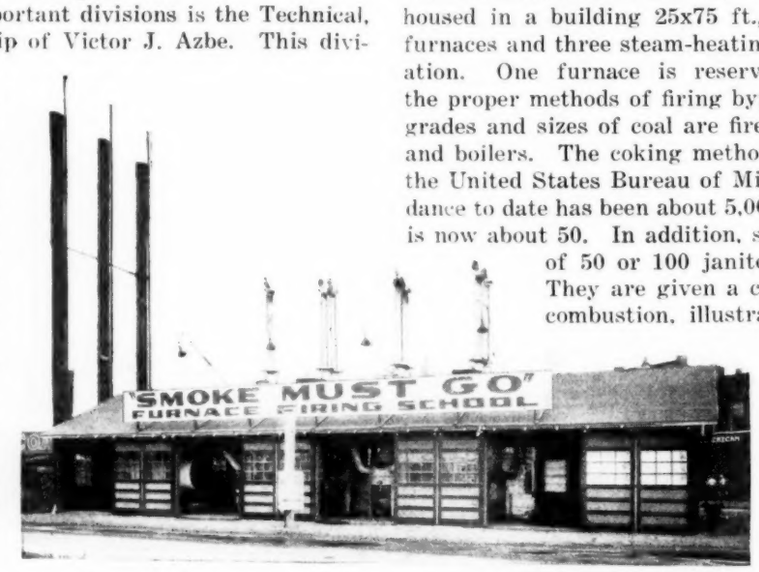
In the educational division the work is organized on a comprehensive scale and twelve committees are working. Luther Ely Smith, a prominent St. Louis attorney, is chairman. The School Committee has prepared a course in heating and furnace firing for use in the junior high schools and the high schools of St. Louis and vicinity, which has been incorporated in the latest curriculum bulletin of the Board of Education. This bulletin is now being studied by the instruction staff and is being tried out in some of the schools.

The speakers' committee has enlisted the services of about sixty men and women, who have agreed to give their services for a comprehensive speaking campaign. Talks already have been made before 150 organizations. The Boy Scout Committee has arranged for distribution of literature throughout the city. Other committees have arranged for janitors to attend the Firing School, for the preparation of material for talks, for distribution of lantern slides to the motion picture theaters and for the preparation of standard firing cards.

An experienced publicity man is now devoting several hours each day to this work, and as a result the St. Louis newspapers carry an article about the activities of the league almost every day.

Being a civic organization, the League is supported by suscription, so that the Finance Division is an important factor. Encouraging response has been received from individuals and corporations. Some $20,000 has been subscribed to date. It is planned to raise a total of $60,000 for the year's campaign.

One of the most important divisions is the Technical, under the chairmanship of Victor J. Azbe. This division is organized with ten committees as follows: Household warm-air furnaces, heating plants, chimney code and household chimneys, clay-products plants, power plants, railroads, central stations, household steam and hot-water boilers, firing devices and a committee on testing and developing firing methods. Through the Railroad Committee the League is co-operating with the railroads. All railroads entering the St. Louis terminal maintain a joint railroad smoke-inspection bureau under the chief smoke inspector of the Terminal Railroad. They maintain their own staff of smoke inspectors, and each road, of course, has its road foremen of engines and fuel supervisors. Smoke Commissioner Gordon estimates that railroad smoke has been reduced 40 per cent in the last two years.



Furnace firing school promoted and financed by the coal and furnace industries of St. Louis

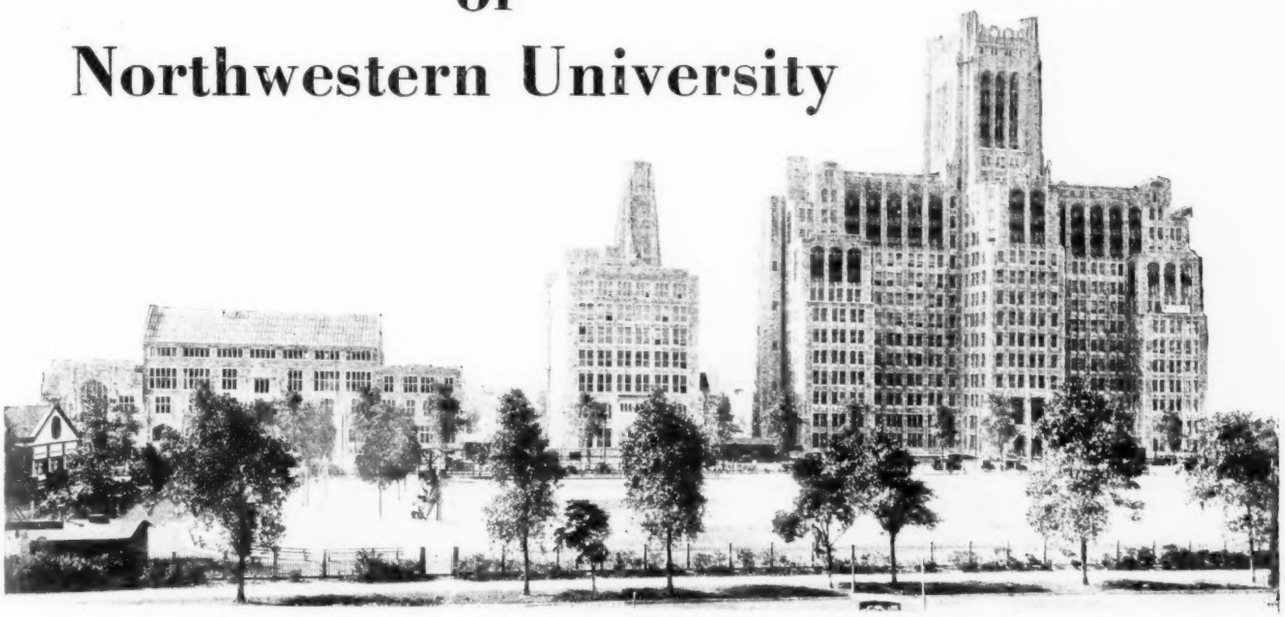
On the Clay Products Plant Committee, which has been doing excellent work, each branch of the ceramic industry is represented. The city smoke commissioner has been concentrating attention on the brickyards and has done remarkably good work. He estimates that the brickyard smoke has been reduced 30 per cent in the last 18 months and that it will be reduced 75 per cent in another year. Some of the large plants are installing tunnel kilns, and practically every plant in the district is installing new fireboxes or steam jets for introducing air over the fire. The outlook is encouraging.

For several months the Technical Division has been conducting research work into methods of firing domestic furnaces. Under the leadership of Mr. Azbe a down-draft baffle has been developed for installation in practically any household furnace. Air is admitted through the firedoor, and the baffle forces volatiles given off from the coal through the hot zone of the fire and mixes them with the secondary air. From exhaustive tests it was found that the use of this baffle greatly increases the efficiency of the furnace and the temperature of the fire. Apparently, it is foolproof and smokeless in operation. The furnace manufacturers of St. Louis are preparing to place this baffle on the market. It can be installed in old furnaces.

The League is co-operating closely with the Smoke Department of the city, which is well organized and for the last 18 months has been doing exceptionally good work. The department has made practically no prosecutions under the smoke ordinance, but is carrying on an educational campaign in which members of the staff work with the plant owners, show them how they can save money by installing new equipment, making changes in their plants or by using new firing methods.

One of the outstanding features of the campaign is the establishment of a furnace firing school. This is housed in a building 25x75 ft., containing six hot-air furnaces and three steam-heating boilers in actual operation. One furnace is reserved for instructions in the proper methods of firing byproduct coke. Different grades and sizes of coal are fired in the other furnaces and boilers. The coking method of firing developed by the United States Bureau of Mines is used. The attendance to date has been about 5,000, and the daily average is now about 50. In addition, special classes consisting of 50 or 100 janitors have been arranged. They are given a comprehensive lecture on combustion, illustrated with lantern slides and then practical demonstrations on the floor. Each janitor attending the school is given a certificate. At this writing plans are being made for Smoke Abatement Week, beginning Jan. 29, when an intensive drive will be conducted.

Heating Plant for Professional Schools of Northwestern University



Alexander McKinlock Memorial Campus of Northwestern University

Ward Memorial on right; Wiebolt Hall in center; Levy Meyer Hall and Elbert Gary Library on left. The gothic tower on Wiebolt Hall screens the chimney.

NORTHWESTERN UNIVERSITY has grouped its new professional schools on McKinlock Campus, situated on the lake shore of Chicago's North Side. These include the schools of medicine and dentistry, housed in the Montgomery Ward Memorial building, the schools of commerce and law and the Gary Library. Plans have been made for the Thorne Auditorium. The remaining two-thirds of the campus, it is intended, will be occupied mainly by hospitals, the first of which, Passavant Memorial Hospital, is already being planned. Next to the campus is the site for Wesley Hospital.

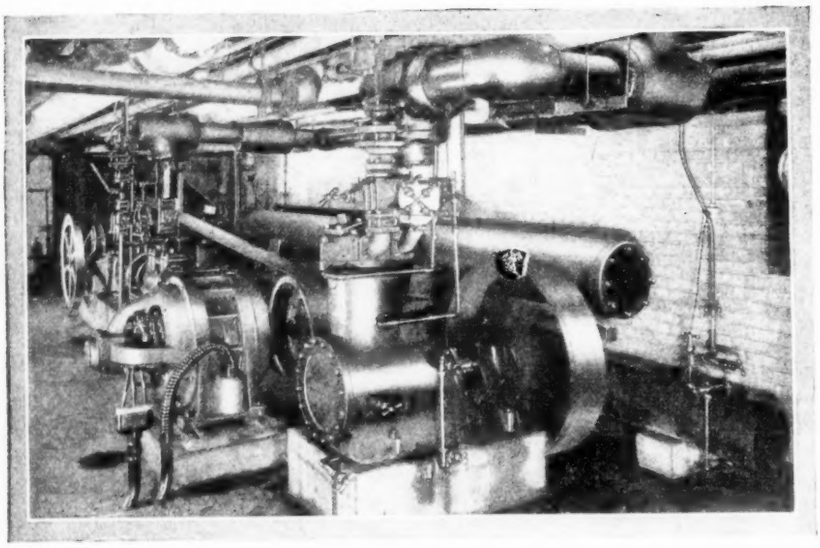
In designing a central heating plant for the present requirements, it was necessary to provide space for future extensions. It was decided that for the present at least, with electrical service required mainly during a comparatively short period of the day, electric power should be purchased, but that the boiler room should be so constructed that if the future dictates a generating plant, none of the present investment will be wasted. To house this central plant the School of Commerce building (Wieboldt Hall) was increased in ground plan so that the rear half of the first and second stories and practically the entire basement should be available for plant purposes. The boiler plant can later be extended to the street without marring the appearance of the building and without interfering with the occupancy of the school. In this way an ultimate boiler room containing twelve units can be provided. The present boiler room was constructed so as to accommodate eight units. Four of these have been installed on one side; the opposite side of the building has been devoted temporarily to other purposes.

FOR the various buildings on McKinlock campus a central plant has been provided to furnish steam for heating and ventilation, refrigeration, compressed air, water and other services. Owing to the short period of service through the day, current is purchased, but space is available for a power plant should this be desirable when ultimate plans for buildings have been fulfilled.

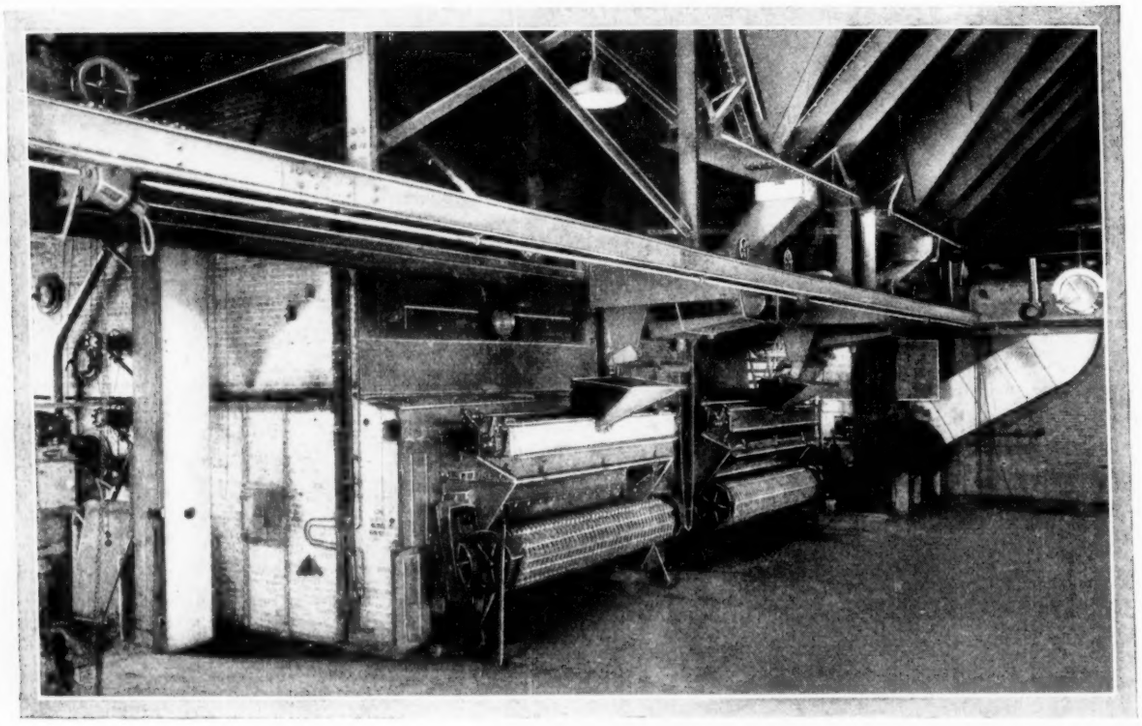
In the central plant are the boilers with practically all heating equipment, together with the centers of all services such as electricity, compressed air, water supply, etc.

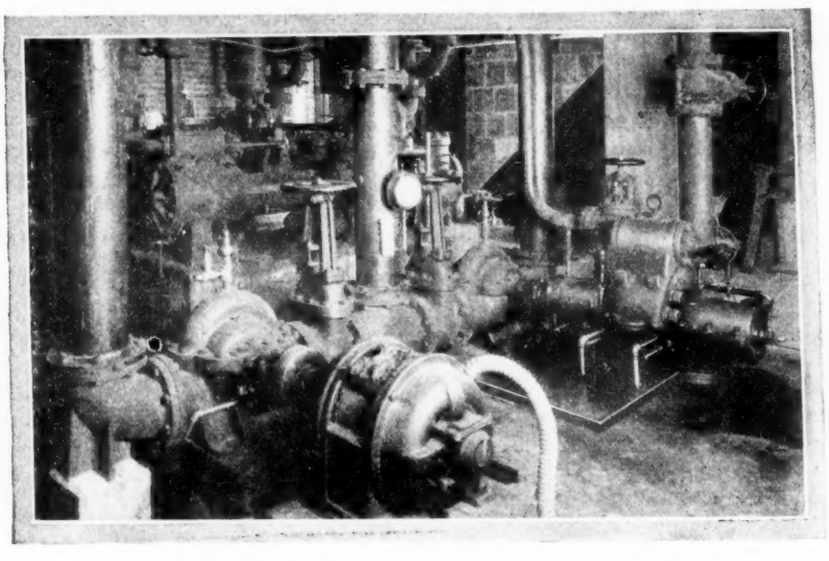
The Montgomery Ward Building, housing the medical and dental schools, is heated by direct steam radiation on a two-pipe vacuum system. There is approximately 45,000 sq.ft. of direct radiation on a two-pipe vacuum system, while the blast heaters for ventilation take roughly the same amount of steam as the direct surface. In the large rooms the direct radiation is thermostatically controlled, while all fresh air supply is drawn through heaters and washers, the former being handled also by means of thermostats.

The building is served by four passenger and one freight elevator, all of the variable-voltage type, the passenger elevators having high-speed gearless machines. The dental school and the medical school have practically independent systems of fresh air supply and



Left — Ammonia compressors, tubular condenser and liquid receiver

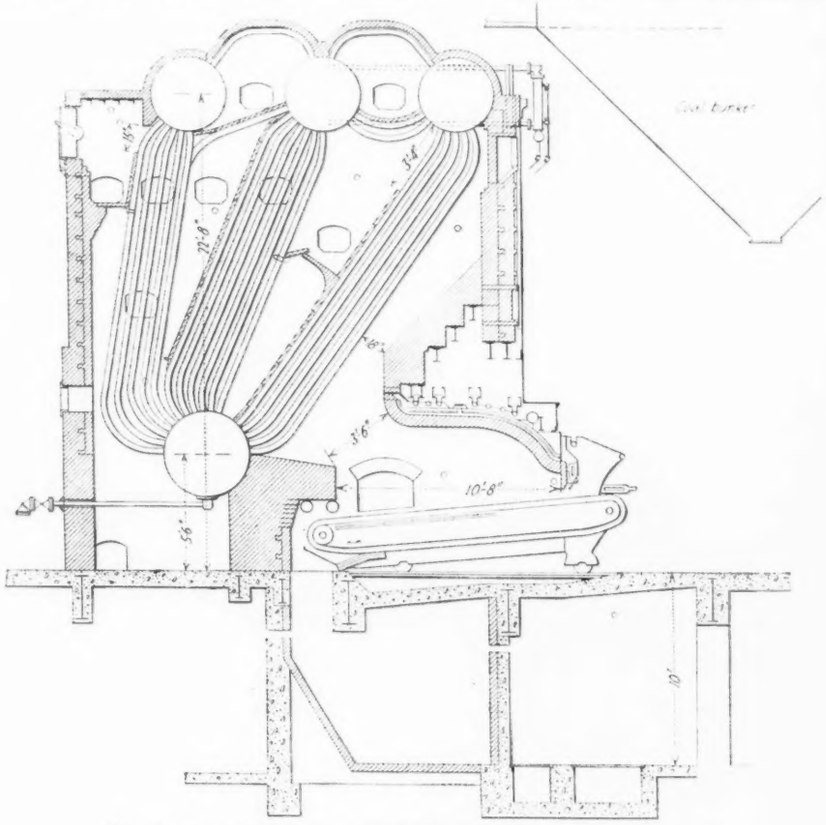




Above — Chain-grate Sterling-boiler installation

Right — Hot-water circulating pumps and feed pumps

exhaust. There are two independent systems of water supply. Centrifugal pumps in the central plant furnish water to an eleventh-story tank, which takes care of the lower seven floors of the building, and an independent pumping system supplies a twentieth-story tank serving the dental school and the tower. The high-level system is supplied by a triplex pump, with a direct-acting steam pump in reserve. The motor-driven pumps are electrically controlled by floats in their respective tanks.



Vertical section through Sterling-boiler setting

All water except what is used for lawns passes through filters and from these into an open surge tank. The discharge into this tank is controlled by float valves. A portion of the water from the filters goes through the compressor jackets and thence into the surge tank. All the house pumps will draw their supply from this tank. Water supply for the lower buildings of the group is controlled by the eleventh-floor house tank in the Ward Building.

Space occupied by the schools of law and commerce in Wieboldt Hall and Levy Mayer Hall is heated by direct radiation, and the class and lecture rooms are provided with fresh air supply and exhaust as well. The blast equipment for the ventilation is similar to that in the Ward Building, but the direct radiation for these buildings is on a hot-water system. On the gallery in the boiler room are two coil heaters that take care of all the radiation in the two buildings and will take care of the direct radiation of Thorne Auditorium when it is built. All auxiliary steam-using apparatus in the central plant exhausts into an open feed-water heater and also into the two heaters supplying these heating systems.

To provide sufficient exhaust, the main vacuum pumps taking care of the steam-heating returns from the entire campus, both direct and blast, are turbine driven. The circulating pump on the hot-water heating system is turbine driven, with a motor-driven pump in reserve. The main air compressor supplying air for laboratory purposes throughout the medical school and also for the thermostats, sewage ejectors, etc., is steam driven, although there is a motor-driven compressor in reserve and available for summer service. The exhaust from these units and from the direct-connected feed pumps furnishes sufficient steam to heat these buildings in mild weather, although the direct radiation is equivalent to about 25,000 sq.ft. of steam surface. In colder weather the exhaust is supplemented by live steam. Thermostatic control is not used on the hot-water radiators, but a thermostatic valve is used to govern the admission of steam to the hot-water heaters, the adjustment of this valve being variable by means of air pressure under control of the chief engineer. A system of telethermometers at the heating control board enables the operator to read temperatures in remote parts of the buildings, so that he can control radiator temperatures as required.

To supply heat during the winter, it is intended to use the three large boilers equipped with chain grates. During the summer there is still a demand for supplying hot water throughout the property and also for sterilizers and for laboratory service. This load is relatively small, and a hand-fired furnace is provided under a small boiler unit.

The main piping of the plant is divided so that when the summer condition exists, the main header, together with all the principal steam piping throughout the property, is out of service and cold. An auxiliary header directly connected to the small boiler supplies steam for the pumps and auxiliaries and also for sterilizing service. To do away with gasket trouble at the beginning of each heating season, the gaskets on these steam lines have been omitted. The boiler header and all the principal valves in the boiler room are of cast steel with bolted steel flanges, sealed by means of welding. Steam to the various heating systems is transmitted at boiler pressure. From the nozzles on the main boilers to the reducing valves on the fourteenth floor of the Ward building there is not to be found a second joint or gasket.

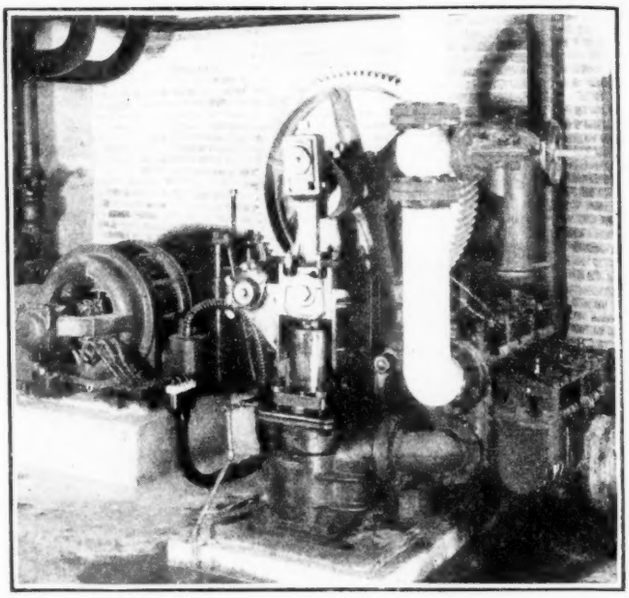
For the laboratories it is necessary at many places to provide cold storage or constant temperature. To take care of this there have been provided in the basement below the boiler room two belt-driven ammonia compressors, one intended for summer and the other for reserve and winter service. These machines run at relatively high speed and are connected with a shell-and-coil brine cooler. The brine circulating pumps, as well as the compressors are motor operated.

A complete compressed-air system operating at 20 lb.

gage is used for the laboratories in the Ward Building. Below the boiler room one steam-driven and one motor-driven compressor take care of this demand, while for the limited high-pressure requirements of the buildings a motor-driven high-pressure compressor with an auxiliary pump has been installed. For fire protection there is a 1,500-gal. per min. motor-driven pump in the basement of Wieboldt Hall.

Coal is brought into the plant either by driving directly into the boiler room or discharging through an opening in the floor or by delivery through numerous openings in the top of the coal-storage bin. This bin has a capacity of between 1,200 and 1,500 tons and is located below grade in the space between the boiler room and the next building. Wagons drive over the top of this bin and discharge into any one of the twenty openings provided. Coal is collected by means of a system of screw conveyors and delivered to the bottom run of the main conveyor which extends the length of the boiler room, its lower flight immediately below the basement floor and the upper flight close to the boiler-room ceiling. This conveyor can receive coal from a feeder where deliveries are made into the boiler room or from the screw conveyor when coal is being taken from the storage. A series of bins in front of the boilers will contain more than enough coal for a night shift. From these pyramidal bins coal is spouted to the stokers through an automatic scale.

Each boiler has a meter panel on which are indicated the steam flow and the air flow. Where the steam is led to the different buildings, orifices are provided and flow meters record the quantity of steam chargeable to each service.



Triplex service pump supplying upper floors

Electric power comes from the public utility into switch and transformer rooms in the basement of the central plant. This current is delivered at 12,000 volts. Separate transformers are provided for 440-volt power service and 110-220-volt lighting service.

PRINCIPAL EQUIPMENT IN NORTHWESTERN UNIVERSITY PLANT

BOILER ROOM

Boilers, three Stirling, 5,160 sq.ft.	Babcock & Wilcox Co.
Boiler, one, Heine type, 2,050 sq.ft.	Brunswick-Kroeschell Co.
Stokers, three, green chain grate, 10x11 ft.	Combustion Engr. Corp.
Grate, one	K. R. Furnace Co.
Chimney, interior, 12½ ft. diam., 190 ft. high	Heine Chimney Co.
Smoke indicator, eclipse	Boiler Room Improvement Co.
Feed pumps, three	Platt Iron Works
Feed-water heater	Cochrane Corp.
Breeching and tanks	American Boiler & Tank Co.
Boiler settings	National Power Cons. Co.
Stoker arches	M. H. Detrick Co.
Insulation	Smith Totman Co.
Coal-conveying machinery	Brady Conveyor Corp.
Soot blowers	Vulcan Soot Cleaner Co.
Boiler meters	Bailey Meter Co.
Feed-water meter	Simplex Valve & Meter Co.
Steam-flow meters, recording	Republic Flow Meters Co.
Steam gages, Asheroft	Manning, Maxwell & Moore
Ash conveyor, jet	United Conveyor Corp.
Coal scales	Richardson Scale Co.
Coal spreaders	Universal Coal Spreader Co.
Draft regulation	Hagan Corporation
Filters, 32,400 gal. per hr.	International Filter Co.
Valves, non-return	Foster Engineering Co.
Valves, steam and water	Crane Co.
Valves, blowoff	Babcock & Wilcox Co.
Cocks, blowoff, gate	A. W. Cadman Mfg. Co.
Safety valves	Crane Co.
Water columns	Reliance Gauge Column Co.
Steam traps	Boylston Steam Specialty Co. Powers Regulator Co.

HOT WATER AND HEATING

Domestic water heaters	Griscom-Russell Co.
Heating system heaters	Whitlock Coil Pipe Co.
Hot-water circ. pumps and turbine drive	DeLaval Steam Turbine Co.
Vacuum pumps	Nash Engineering Co.
Turbine drive for vacuum pumps	Moore Steam Turbine Corp.
Fans and air washers	American Blower Co.
Direct radiation	American Radiator Co.
Blast heaters	American Radiator Co. Aerofin Corp.
Thermostatic control	Johnson Service Co.

COMPRESSED AIR

Air compressor, steam, l.p., 9x8x12 in.	Ingersoll-Rand Co.
Air compressor, steam, hp.	Westinghouse Trac. Brake Co.
Air compressor, motor-driven, l.p., 9x8 in.	Sullivan Machinery Co.
Air compressor, motor-driven, hp., 7x6 in.	Ingersoll-Rand Co.
Refrigerating equipment, including 22.5-ton hor. and 10.8-ton ver. compressors	Carbondale Machine Co.

PUMPS

Centrifugal house pumps, two, 250 g.p.m.	Worthington Pump & Mach. Corp.
Triplex house pump 7x10-in.	Worthington Pump & Mach. Corp.
Fire pump, cent., 1,500 g.p.m., 200 lb.	Dayton-Dowd Co.
Sewage ejectors, pneumatic	Yeomans Bros. Co.

ELECTRICAL

Motors	General Electric Co.
Switchboards	Marquette Elec. Swbd. Co.
Air circuit breakers	Cutter Co.
Oil circuit breakers	Condit Elec. Mfg., Co.
Watt-hour meters	General Electric Co.
Indicating meters	Weston Elec. Instr. Co.
Fire-pump control	Sundh Electric Co.
Time system	Stromberg Electric Co.
Remote control	General Electric Co.

ELEVATORS

Ward Building:	
Passenger, four, gearless traction, Wagner pneumatic gates, 2,500 lb., 600 ft. per min.	Kaestner & Hecht Co.
Freight, one, geared traction, 3,500 lb., 350 ft. per min.	Kaestner & Hecht Co.
Low lift, one, a.c. motor, 2,500 lb., 250 ft. per min.	Kaestner & Hecht Co.
Motors and generators	Westinghouse Elec. & Mfg. Co.
Wieboldt Bldg.:	
Passenger, two, gearless traction, 3,000-lb., 450 ft. per min.	Otis Elevator Co.
Motors and generators	Otis Elevator Co.

CONTRACTORS AND ENGINEERS

Structural work	Hansell Elcock Co.
Masonry foundation	R. C. Wieboldt Co.
Architects	Jas. Gamble Rogers, Inc., New York Childs & Smith, Chicago
Piping and heating	W. A. Pope
Ventilating	Narowetz H. & Vent. Co.
Plumbing	O'Callaghan Brothers
Electrical construction	McWilliams Electric Co.
Engineers, consulting	W. L. Fergus & Co.

Quality of Brine Influences

Refrigerating Plant Records

By FRANK P. MacNEIL

IN CONSIDERING the measurement of refrigeration by calculating the heat taken up by the brine, there are some factors that merit more consideration than has apparently been bestowed upon them.

An error in the specific heat or in the number of gallons circulated will entail a serious error in the results desired. Consequently, when one considers the numerous tests that are constantly being made and is conscious of the dearth of reliable information on brine, one cannot but feel skeptical of the accuracy of some of the results obtained.

In the matter of tests of small plants, where the amount of brine circulated is relatively small, the brine result may be made to check closely with other results; but where the measures are large, an error will assume serious proportions, although of no greater percentage.

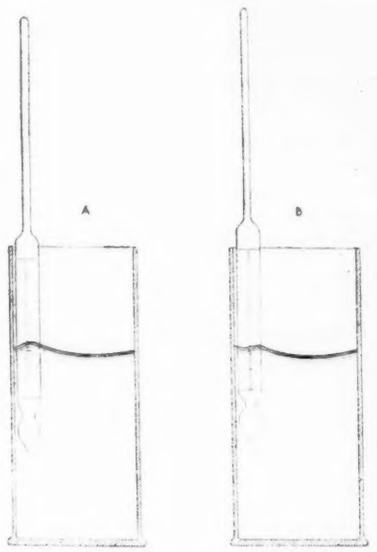
To determine the specific heat and the weight of brine circulated, a knowledge of the exact specific gravity is necessary. It appears to be a simple matter to obtain the exact value, but experience with some of the hydrometers now available will cast some doubt upon the supposed simplicity. Some are graduated at 39 deg. F., others at 60 deg. F., still others at 64, and some at 68. One manufacturer of calcium chloride distributed a 68-deg. hydrometer and, when requested for a table of properties of his brine, furnished a table compiled at 64 deg. Four different makes of hydrometers graduated for $CaCl_2$ at 60 deg. gave different readings when tested together in the same bath. If a narrow glass hydrometer jar is used, surface tension appears to hold the hydrometer if it rests against the side of the jar. The hydrometer appears to give a different reading if allowed to remain in the sample as it rises to the desired temperature, as at *A* in the illustration, from what it does after it is taken out and put in again at the desired temperature as shown at *B*.

It is often difficult to locate the exact meniscus, and many times a wrong reading is taken.

As 4 deg. C. or 39.2 deg. F., appears to be the most logical point at which to graduate hydrometers, why introduce a complex ratio, as the Bureau of Standards does when it defines specific gravity as the ratio of the brine at 60 deg. to water at 39.2 deg.?

Why cannot we have a simple ratio, both at 39? Then when we say the brine is 1.225, all will know that it is that number of times heavier than water at 39 deg. F. Another advantage is that brine is usually measured for gravity while it is circulating in the system and consequently quite cold. Why wait until the sample crawls up to 60 deg., when it will jump up to 39 deg. in one-quarter of the time? This will obviate heating the sample to hurry it, with consequent mistakes, and it is a more handy point all around. A hydrometer finely graduated over the useful range and with a thermometer incorporated within it, will give more accurate results than the methods employed at present. The 39-deg. point on the thermometer may be marked in red. The sample should be stirred to secure uniform temperature.

A standard-size hydrometer should be decided upon, as there are brine hydrometers two feet long, while others are six inches long. Care should be exercised that the hydrometer is floating and not resting against the side of the vessel. For this reason a glass



Method of placing hydrometer influences readings

hydrometer jar is to be desired, because many times the brine is clear enough to read the thermometer, and this will obviate constant removal of the instrument with the attendant possibility for error. A glass jar will also allow the condition of the brine to be observed as regards corrosion, but it must be borne in mind that the refraction index of strong calcium brine is high, and errors from this source should be guarded against.

As Venturi meters are now being used to measure brine flow and as it is necessary to know the difference in weight of the brine between that at which the meter was calibrated and that at which it operates, an exact knowledge of the increase in density is essential, to apply corrections.

As specific heat decreases and density increases as the temperature is reduced, there should be clear and concise tables showing the change in specific heat for each degree alteration in gravity. As the useful range over which it is desired to obtain these figures is not a wide one, being in most cases from +25 deg. for fruit to −20 deg. for fish, the heats and gravity should be measured, not exterpolated, as is done in most cases. It

has been shown repeatedly that exterpolation is not always reliable. The pounds per gallon could be worked out for each gravity, also the pounds per cubic foot. Now this heat content per pound from 32 deg. F. does not seem to be very reliable; for instance, in Mueller's table the heat content from 32 deg. of a 1.220 brine at —9 is —28.18 while the content at —11 is —29.54. Subtracting, we have 1.36 B.t.u. divided by a two-degree range gives 0.68 B.t.u. per lb. After all this manipulation we leave only two figures in the specific heat where we actually need four. Multiply this by over 10,000 lb. circulated per minute and the result is apparent—two or three tons of refrigeration could be lost sight of on a large job.

It is much simpler to give the exact specific heat and the exact weight per gallon at the various temperatures; then there is something tangible to work with. It would be easy enough to find the mean between inlet and outlet temperatures and the rest would be simple. The exact specific gravity should be found for every degree in this range.

Effect of Viscosity

As regards viscosity a great fund of information of vital importance could be brought to light if this and conductivity were investigated. There seems to be an idea prevalent among engineers that a brine with a large specific heat will do more work than one with a small specific heat. The reverse of this idea is what really appears to be a fact. In the definition of the British thermal unit the time element is not taken into consideration, but in its conversion to work, that is, 777.5 ft.-lb. per min., time acts as a vital factor.

Now if we take time into consideration in dealing with specific heat, we can see where this idea is in error. Let us suppose that we have two samples of brine each of exactly a pound weight. The specific gravity of one is 1.220 with a specific heat of 0.671, and the specific gravity of the other is 1.240 with a specific heat of 0.655. Now we propose to heat each of these samples through one degree and note the time it takes in each case. For this purpose let us suppose, to avoid taking into consideration the complications of heating in a calorimeter, that we have two bunsen burners each capable of imparting to these samples exactly one B.t.u. in one minute. It is obvious that the 1.220 sample will take 0.671 min. to heat the one degree, while the 1.240 sample will take 0.655 min. to heat the same amount. Now if the heat is kept on for one minute, the 1.220 sample will have risen 1.475 deg. and the 1.240 sample 1.526 deg., a difference of a twentieth of a degree; but they have both taken the same amount of heat. Here we have two substances taking exactly the same amount of heat, but showing different temperatures. The 1.240 sample is a much better conductor of heat than the 1.220 sample.

Reliable data on this subject would show where a gain could be effected, that does not appear obvious now. In the absence of reliable information, it is only conjecture concerning the time element, but when considered in connection with the molecular theory, there are strong indications that the dense brine absorbs heat and discharges heat with more avidity than does a less dense brine. If there are two brine circuits, identical in every respect, each passing through the same refrigerated space, and in each circuit there is being circulated 1,000 gal. of brine per minute, it will be found that if one carries a denser brine than the other, the one with the stronger brine will bring back more heat to the cooler despite all evidence to the contrary.

In the foregoing it was assumed that each sample took heat at a constant rate, but there is strong evidence to suppose that such is not a fact. As temperature is a measure of molecular vibrations, and indirectly a measure of speed, it follows that it takes less heat to produce the same speed in a given time or less time to produce the same speed with a given heat, therefore as refrigeration is measured by time and heat, the circuit that will take up heat the quicker will deliver more to the cooler.

It is obvious that the time element will be also proportional to the temperature gradient in each case; that is, if it takes a certain definite time for a certain gravity at a certain temperature, with a certain gradient, then by increasing the gradient the time factor will change, as it will for a change of gravity or a change of temperatures.

The specific heat decreases as the temperature decreases, so that conductivity must increase. If it does not, then something must compensate for the decrease in specific heat. The speed of the molecules is reduced and their freedom is restricted. It now takes less energy to accelerate them than it did at a higher temperature. As temperature is produced by the speed of the molecules and volume by their freedom, it is reasonable to suppose that conductivity will be improved.

Brine traveling through coils has a certain time in which to receive energy, depending on the rate and nature of the flow; that is, whether it be viscous or turbulent. It would appear nonsensical to say the flow approaches a viscous state, but when one considers the length and nature of some of the paths through which brine is made to flow, the idea is not so nonsensical as it seems to be.

Branch circuits will have varying rates of flow, and if the flow is below the critical speed, it will be viscous. That the density will determine the critical speed seems obvious.

If a viscous flow is present in a circuit, the outside layers will be warmer than the central ones, for the outside layers are traveling at a slower speed. This condition is not so conducive to good heat transfer, as is a turbulent flow, where the brine tumbles along the pipe and by its action does not allow a warm film to exist.

It may be deduced that while density may enhance conductivity, it may offset this gain by tending to cause a viscous flow where speeds are low. On the other hand, erosion at bends from high brine speeds is a factor to be considered with dense brine. Instances are known where the metal in the bends became so thin that it could be easily pierced with an ordinary penknife.

Increase in power consumption of brine pumps, not alone from viscosity but from increased weight per gallon, is another factor to be considered. As the power expended in moving the brine is work done on the brine and has to be taken care of by the refrigeration machine in the form of added B.t.u., it is evident that there is a point beyond which it is not economical to go with respect to density and speed of brine. A greater weight per gallon may be circulated at greater densities and thus take up more heat per gallon, but it is not a clear gain.

Testing Flow in Metals at Various Temperatures

By L. W. SPRING,* H. W. MAACK and J. KANTER

IN THE September 1, 1925, number of *Power*, two of the present authors published an article entitled "Accuracy in High-Temperature Testing of Materials," which described in detail an electric resistance coil used for heating a test specimen while in the testing machine and gave tables showing comparative temperatures obtained at various locations in the specimen with the furnace wound in different ways. The present article deals with new machines designed for accurate testing of flow or creep in metals in which the test specimens are subjected to the maintained high temperatures and pressures prevalent in modern practice. Materials having tensile strengths up to 250,000 pounds per square inch may be tested.

IN MODERN electric power plants temperatures and pressures are maintained continuously over long periods of time, as shutdowns are infrequent. Temperatures up to 750 deg. F., with pressures of 600 lb. and in one or two cases 1,200 lb. per sq.in., are in use commercially. Similar conditions of high temperature and pressure hold good in present-day oil refineries, with temperatures often running to 900 deg. F. and pressures from 500 to 1,000 lb., although, naturally, they are maintained for much shorter periods.

Such service naturally urges as close duplication of operating conditions in a test of materials as it is possible to attain. Therefore, modern investigators are making use of maintained temperatures and pressures in their tests of materials to be used in such installations.

For tests at the Crane laboratories it has been necessary to design special machines, inasmuch as the regular laboratory physical testing machines could not be spared for such long periods of time as would be necessary, and furthermore, such machines are not as adaptable or as accurate for "long-time" testing as are the simple lever, dead-weight machines. Since, so far as known, no machines for "flow" or "creep" testing are on the market, each investigator has had to design and build his own.

*Chief chemist and metallurgist, Crane Company

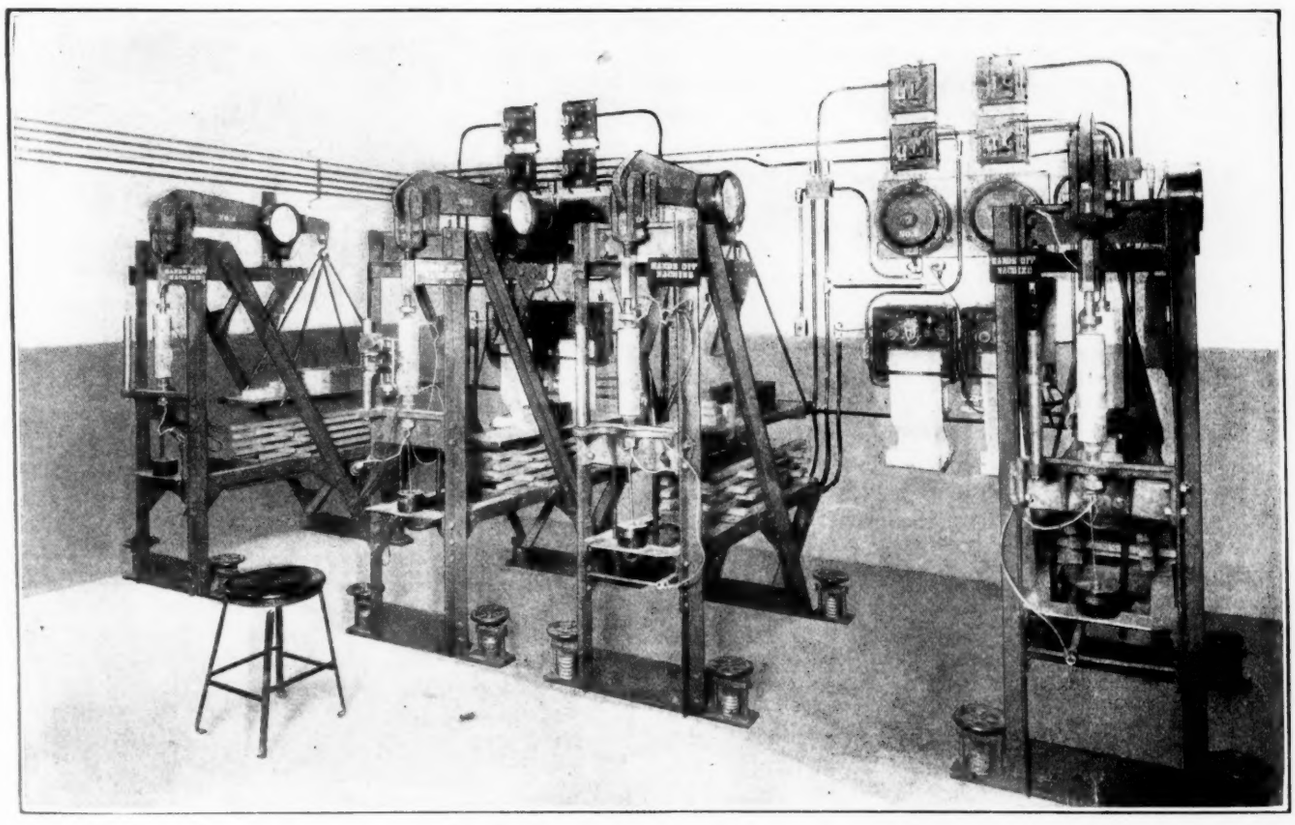


Fig. 1—Four of the five machines in service for the measurement of flow or creep in metal at various temperatures

The machines used in the company's laboratories were designed there and were built in the company's shops; only the lever, the electric controller-recorder and the mechanical motion-recorder were purchased. Figs. 1 and 2 illustrate these machines, five of which now are in practically continuous operation. For levers, part of the calibrating apparatus used for checking the tensile testing machines was used. The two levers, made immediately available, and the knife-edges were considered a real asset. These levers give a 9 to 1 ratio pull on the test specimen to which they are directly connected through self-centering socket holders into which the threaded ends of the bar are screwed. Standard weights piled on the bales give the pull desired on the test specimens, which are anchored by means of the lower self-centering holders to rigid, cast-iron cross-beams. The machines have springs at the four corners to absorb any vibration or shock, for specimens, when at high temperature and loaded for a long time practically to capacity, may undergo change or break prematurely if subjected to jar.

Test specimens are turned either to the standard 0.505 in. diameter or to ½ in. diameter, the former being used for tests at higher temperatures where the lowered strengths due to temperature will not be subject to as great inaccuracy as would be the case if specimens of smaller cross-section were used. Further, the greater oxidation brought about by the higher temperatures is not such an important factor with test specimens of larger diameter.

A gap-wound furnace is used similar to that described in the previous article, except that for this application five inches have been added to its length.

Temperature Control Maintained by Use of Two Thermocouples

Temperature control is maintained by the use of two thermocouples in axially drilled holes in the top and in the bottom of the specimen. These holes are drilled to within ½ in. at both ends of the 2-in. breaking section. Closer temperature regulation is obtained with two than with only one thermocouple. These thermocouples connect with a Leeds & Northrup controller-recorder which cuts off current from the heating coil when the temperature gets 5 to 10 deg. F. above that desired and cuts it in again when the temperature of the specimen sags 5 to 10 deg. F. below. This regulation, of course, results in the well-known wavy line drawn by the pen on the recorder sheet. In addition, a Bristol motion-time recorder is mounted on top of the machine, its lever resting upon the main beam so that its pen marks on the chart all movements of the main lever as the test specimens stretch or break.

As each test continues for a shorter or longer time, circles are being marked on the chart, one for each 24-hour revolution of the chart. The circles are practically coincident up to the beginning of rapid plastic deformation, usually considered as indicating the yield point of the specimen, and concentric but larger and larger as the bar stretches. The sensitivity of the machine is such that these waves on the temperature recording chart are repeated in much smaller waves on the Bristol motion-time chart, drawn by the motion of the beam. These two sets of waves synchronize, showing that the expansion and contraction of the specimen, from its alternate heating and cooling over a range of 10 to 20 deg. F., moves the lever freely upon the knife-edges. When the specimen breaks, the pen leaves a record of the exact time, as it has been doing of all length changes taking place in the specimen throughout the test.

When the break occurs, a cutoff switch, placed beneath the lower holder, is operated by the dropping of the holder and the bottom half of the test specimen. By means of this device all current is cut off from the regulator and heating coil, and the entire apparatus remains "dead" until an attendant starts it on a new specimen. The stopping of the regulator-recorder, of course, shows the time of the breaking of the specimen.

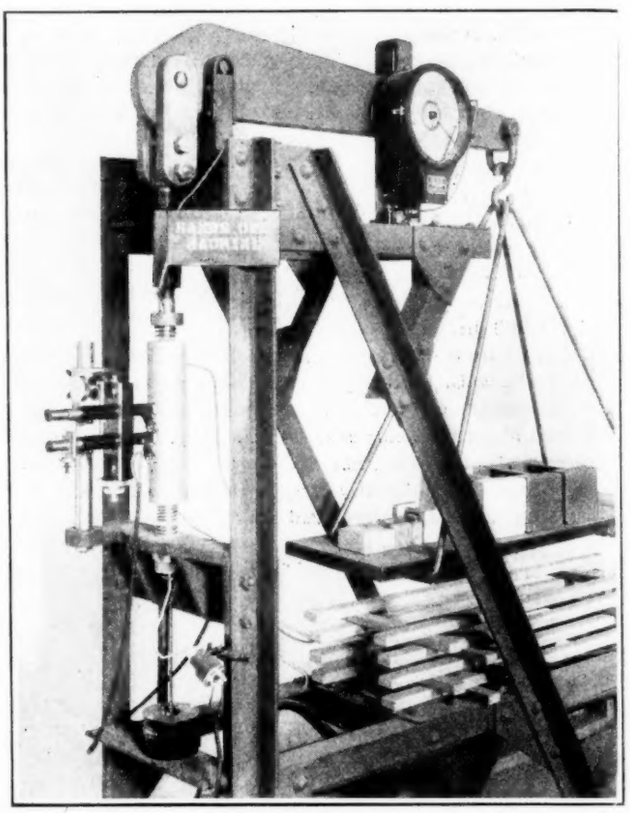


Fig. 2—Close-up of one machine, showing the Bristol motion-time recorder at the top and the two-telescope extensometer opposite the specimen

This is desirable since it is not customary or necessary to have an attendant present day and night.

While the Bristol motion-time recorder gives a rough measure of the stretching of the test specimen, it does not give results of high accuracy. Therefore, measurements are taken daily or oftener by means of a two-telescope extensometer built specially by the Gaertner Scientific Corporation, of Chicago. The two telescopes with adjustable eyepieces are mounted a fixed distance apart, operated independently or together by means of an accurate lead screw. These telescopes are provided with cross-hairs, and one with a filar adjustable eyepiece. Both are provided with illuminating lamps which throw light through holes in the heating coil upon fine platinum wires, No. 36 gage, B. & S., anchored two inches apart around the breaking section of the test specimen.

Two telescopes are used for measuring extension, since the use of one would cause considerable wear on

the screw as well as unwarranted expenditure of time in moving the telescope back and forth from one position to another over 2 in. of fine lead thread. By means of this extensometer, which is moved from machine to machine, movements over the gage length of the test specimen can be read within 0.00005 in. Attempt is being made to adapt the Tuckerman-Martens' type of extensometer, reading to 0.000004 in. to this service.

In lieu of the No. 36 gage platinum wires to measure

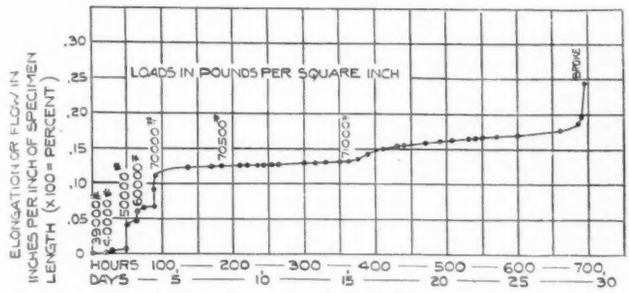


Fig. 3—Strain-hardening of 0.23 per cent carbon cast steel at normal temperatures by gradually increased loads

Loads of 39,000 and 40,000 lb. per sq.in. making little impression, 50,000 lb. was put on. This produced immediate flow (stretch) in the test specimen to 0.004 in., which gradually slowed down and then practically stopped flowing at 0.015 in. At 50,000 lb. the test specimen again stretched for a short period and also at 70,000 lb., each time slowing down and finally stopping on account of strain-hardening. The specimen meanwhile had been growing thinner on account of stretching (now fully ¼ in. in its 2 in. of length, that is, an elongation of 12½ per cent). A new increase of load to 71,000 lb. produced rather fast stretching and finally quick rupture after 695 hours total time and 24 per cent of total flow.

length movements, square-cornered shoulders or sharp ridges, approximately two inches apart can be turned upon the test specimen itself, or comparative length during elongation can be measured against the end of a 2½-in. platinum strip riveted to the upper end of the test bar and extending along the breaking section nearly but not quite to the lower gage wire. In the latter case, only one telescope is needed.

Illustrating the Applicability of the Machines

This article is not intended to be a report of work done, but two illustrations are presented to show the applicability of the machines. It is now well known that steel and many alloys are made stronger (strain hardened) by what is known as cold working, such as stretching or deforming by bending, twisting, etc., at temperatures well below red heat. Commercially, this occurs during the cold rolling of steel plates, the cold drawing of wire, tubes, etc., and continuance of such cold working to bring the articles down to the sizes desired without increased brittleness sufficient to cause rupture, is possible in the steel plant only by annealing after every few passes through the rolls or drawing dies.

This so-called "strain-hardening" occurs through the metal being stressed beyond its elastic limit or yield point, and this is illustrated readily in physical tests in the laboratory. The hardening of the tensile test specimens during elongation (cold work) in the testing machine requires application continuously of greater and greater stress to overcome the supposed keying action of broken-down crystals in the metal, such being indicated by microscopic examination of the specimen.

Fig. 3 shows the life history of the test of a specimen of 0.23 per cent carbon cast steel, tested at ordinary temperature, 70 deg. F., in one of the flow-test machines described previously, with elongations carefully measured by the two-telescope method. In this test, as in high-temperature flow tests, weights are piled upon the platform suspended from the beam, which is protected from uneven application of weights and jar by a carefully adjusted screw beneath. Upon release of the screw each load remains constant until further weights are placed on the platform.

"Strain Hardening"

As explained in the caption of Fig. 3, after each increase of load the specimen stretched somewhat, as indicated by the vertical portions of the graph, such stretching becoming slower and slower, shown by the rounding off of the vertical into the horizontal, until, each time, stretching finally was stopped almost completely through sufficient strengthening of the metal. After many such increments of load, each causing repetition of the foregoing cycle of changes brought about in the specimen, the stretching eventually became continuous under the final load, and the specimen soon broke at what was approximately its normal tensile strength. The stretching and thinning of the specimen, which is possible only at and above its yield point, in reality amounted to "cold work," which, with each load, strengthened it sufficiently to stop the stretching and to make necessary still greater load to produce further deformation or stretch. This, as stated, occurred at practically all loads between yield point and the ultimate or tensile strength of the specimen.

What may be called a sequel to this "strain hardening," also well known of course, but given here in

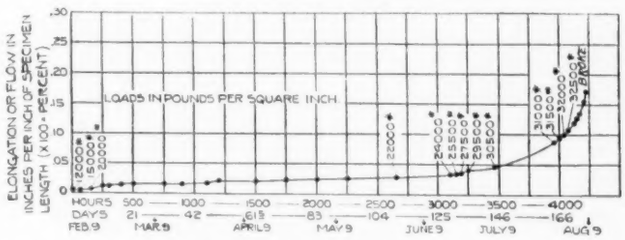


Fig. 4—Flow test of 0.23 per cent carbon cast steel at 800 deg. F.

This six months' continuous test (4,226 hours) at approximately the top of the strain-hardening range was made by loading to 20,000 lb. per sq.in., and holding at that load for 2,437 hours, then making several increases in the load to produce final stretch and rupture.

connection with Fig. 4 illustrating a half-year flow-test under temperature in the machines described, is the automatic relieving of the "strain hardening" by heat. In the steel plant annealing usually is done at temperatures of redness or sometimes below, but usually at temperatures considerably higher than those really necessary. Strain-hardness with attendant brittleness in ordinary low- or medium-carbon steels is overcome or the tendency largely nullified in the regular high-temperature tests of steel at 800 to 900 deg. F., as these temperatures are sufficient to prevent any considerable amount of strain-hardening.

Fig. 4 gives the records of another test on a specimen of this 0.23 per cent carbon cast steel under a continu-

[1] French, "Methods of Test in Relation to Flow in Steels at Various Temperatures," A.S.T.M. Proceedings, 1926.

ous temperature of 800 deg. F. The first load of 12,000 lb. per sq.in. was increased to 15,000 lb. and then to 20,000 lb. during the first 150 hours of the test to bring about continuous stretching (flow or creep), which increased during the succeeding period of 2,400 hours from 0.01 to 0.025 in. per inch of length, indicating 1 to 2.5 per cent elongation in two inches.

During the next 1,000 hours loads were increased from 20,000 lb. to 30,500 lb. in the increments shown. From this point on flow increased rather rapidly from 0.045 in. per inch (4.5 per cent elongation in 2 in.) and then more rapidly with increased loads intended to hasten fracture, until with the application of the maximum load of 32,500 lb. per sq.in. the elongation increased from 10 per cent to 17 per cent at fracture. The yield point of this material, tested cold, is 42,750 lb. per square inch.

As will be seen from a comparison of Fig. 4 with Fig. 3, there are no such evidences of quick extension followed by slower and slower stretching after increased loads, as are shown in the vertical parts of the curve in Fig. 3 after each addition of 10,000 lb. or so. Naturally, increments could not be as great in the 800-deg. F. test. The strain-hardening, however, was prevented largely by the furnace temperature of 800 deg. F., continuously maintained.

An interesting phenomenon, not yet satisfactorily explained so far as known, but mentioned[2] as long ago as 1884, was brought out by use of these machines. A specimen held at temperature in one of the long-time high-temperature tests under rather light load actually grew shorter during the early part of the test. This at first was thought to indicate an inaccuracy in measurement, but other instances confirmed it. Recently, one material under test at 1;400 deg. F. at the light load of 100 lb. per sq.in. showed shrinkage great enough during the early hours of the test to register on the chart of the motion-time recorder which is not the most accurate apparatus for measuring elongation. Whether such "shrinkage" in certain materials, usually heat-treated ones, at temperatures below the critical range is due to some molecular change brought about in the material through relief of heat-treating strains or indicates readjustments following removal of the outside layers during machining of the specimen, or results from other cause, is not yet known. It is possible, of course, that the more pronounced change found at 1,400 deg. F. has to do with the critical range. It did, however, demonstrate the sensitiveness of the machines.

The machines are designed for the testing of materials of as high as 250,000 lb. per sq.in. tensile strength. This capacity is desirable because materials of much higher strengths probably will have to be considered before long in the field of high-temperature engineering.

A Regulator for Maintaining Constant Pressure at the inter-cylinder bleeder connection of a compound engine was described in the Jan. 21 issue of *Engineering*. Steam from the bleeder main leaks through a small spring-loaded valve into a chamber with an adjustable leak-off connection. Rising pressure in the bleeder main raises the pressure in the chamber, forcing mercury into a float chamber. The float acts through a pilot valve, servo-motor and linkwork to lengthen the low-pressure cutoff, thus lowering the bleeder pressure. The high-pressure cutoff is controlled solely by the speed governor.

[2]Thurston, "Materials of Engineering, Part III."

Some Uses for Thermometers

By J. R. Belknap

A bit of mercury in an elongated cavity in transparent glass was one of the oldest and simplest of instruments, yet the difficulties of manufacture were so great that only in recent times has it been possible to obtain accurate thermometers at low prices.

There are many modifications, of course, but the simple mercury thermometer answers most purposes around power plants and industrial operations. The uses for taking steam and water temperatures are well known. Good operation of condensers is practically impossible without them, and how great is the importance of good condenser operation! My experience has been that, when well installed a thermometer is far more reliable for measuring vacuum than the usual layout of mercury gage and barometer. A great number of possible errors are bypassed. There is, of course, the greater time lag in the event of sudden changes of vacuum.

In the absence of steam-flow meters on each boiler, good recording thermometers on the uptakes may be utilized to an extent not appreciated by many. The uptake temperatures will give a very practical indication of the load on a boiler when the load characteristics are known. Of course, many objections come to mind. The percentage of CO_2 will affect it, but not to the extent that may be imagined, for the changes of volume of gases and rate of heat transfer largely cancel the effect of the changes of furnace temperature. It is suggested that the reader check this up on his next boiler test.

Dirty heating surfaces, inside and out will affect the uptake temperature also, but boilers that are set over smoky furnaces and that are fed scale-forming feed water belong to the limbo of the past, and it is clearly the duty of every engineer to see that they get there as soon as possible.

If the uptake temperatures fail to give a good indication of the boiler load, something is wrong. They have one advantage over flow-meter readings in that changes in rate of feed do not affect them appreciably. Here we come to another point.

Is it not better economically to divide the load between boilers on the basis of uptake temperatures rather than equal per cent of rating?

A large factory taking central-station power suddenly faced a penalty for low power factor. There were some 900 motors connected, practically all induction motors. The total of the connected motor ratings was about twice the recorded peak load (hence the low power factor). To go over that many motors with portable wattmeters would have been a considerable task, so we purchased a number of Centigrade thermometers. Then we attached the thermometers to the motors according to A.I.E.E. rules, and took readings. Some were 40-deg. motors, some 60-deg., and that was taken into account. Then we switched those motors around, traded for and bought a few small ones, and had some large ones left over. It took time, and we checked occasionally with the portable instruments. We believe to this day that we did a better job than if we had relied exclusively upon even portable recorders. The temperature rise is the basis of the manufacturer's ratings. Some of the motors were in hot places and that had to be taken into consideration.

The F. Krupp Works Builds Solid-Injection Diesel

THE drift toward the airless injection oil engines is recognized by F. Krupp. This type is standard for medium powers. Experiments made on a 1,000-hp. cylinder.

AS IS the case with almost all European builders of air-injection Diesel engines, Fried. Krupp has developed a line of solid-injection units.

The cylinder head and fuel-pumping mechanism of a 520-b.hp. four-cylinder, four-cycle engine operating at 214 r.p.m. are shown in Fig. 1. The piston is of typical Krupp design, being furnished with a mushroom-shaped hot plate, inserted in the crown. The fuel sprays directly upon this plate, insuring combustion and at the same time eliminating danger of piston crown fracture. It will be noticed that the cooling water to the cylinder head is led in through goosenecks, and the stream is directed toward the center of the head when the greatest amount of heat is absorbed.

The inlet valve shown in Fig. 2 is individual in character, being fitted with a guard which partly blocks the inlet ports and serves to impart a swirling motion to the incoming air. This construction is somewhat similar to the Hesselmann design described in *Power*, June 12, 1923.

The spraying is obtained by a pure pressure atomization which is better adapted to large cylinders than the precombustion chamber atomization employed in small engines.

Atomization requires a fuel-pump discharge pressure of at least 4,400 lb. per sq.in. for efficient combustion. When lower pressures are used, poor indicator diagrams result, all of which show after burning and incomplete utilization of the available heat.

Little Danger from Clogging

The spring of the fuel valve, Fig. 2, is sufficiently strong to enable the fuel pump to build up the pressure before the valve is lifted. The nozzle of the valve has four openings 0.0236 in. in diameter. Practice has, however, shown that there is little to fear from clogging of the orifices. Evidently, the high fuel pressure and high velocity that result serve to keep these small passages clean, for these small borings remain clear and function in a satisfactory manner.

However, it cannot be denied that the danger of clogging becomes more remote as the diameter of borings increases, which also facilitates the manufacturing. On the other hand, the small-diameter borings have one essential advantage, namely, their tendency to confine the pressure atomization in a downward direction. In contrast to this the precombustion chamber atomization is free from such restriction. This is true because the bore of the single hole nozzle in the valve of even a very small engine is still sufficiently large to offer no appreciable restriction.

A further factor that influences the downward atomization is the tightness of the fuel pump. The required high fuel pressure can be attained only with a tight pump. The difficulties arising in keeping the pump tight increase greatly as the size of the pump decreases. The ratio between the circumference of the plunger and the cylinder volume grows more unfavorable, and it becomes extremely difficult to grind the long thin plungers and stuffing boxes to a tight fit without danger of seizure.

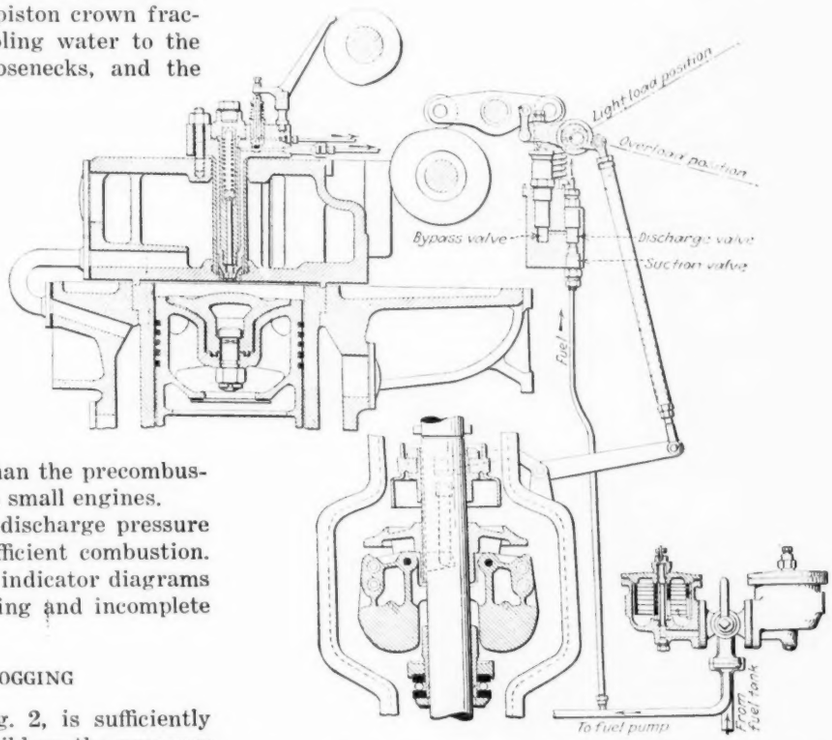


Fig. 1—Cross-section of Krupp cylinder head and pump

The method of governing, as shown in Fig. 1, is of particular interest. The governor regulates the amount of fuel injected, but this regulation is obtained in a different manner from that in the usual Diesel, where the engine governor holds open the inlet valve of the pump for a longer or shorter period as required to change the amount of fuel supplied. In this case the pump delivers pressure directly to the cylinder and not to an independently regulated fuel-injection valve; the beginning of the pressure period remains unchanged regardless of the load.

For this reason the governor controls the opening of a bypass valve connected with the pump cylinder. The beginning of the fuel delivery, its duration and the

quantity of fuel handled by the pump remain unchanged for all loads, but the delivered quantity of oil to the injection valve varies directly with the engine load. Part of the fuel enters the engine cylinder and the remainder is bypassed to the suction side of the pump. The bypass valve on the pump is lifted during every power stroke and closes again by spring pressure. The

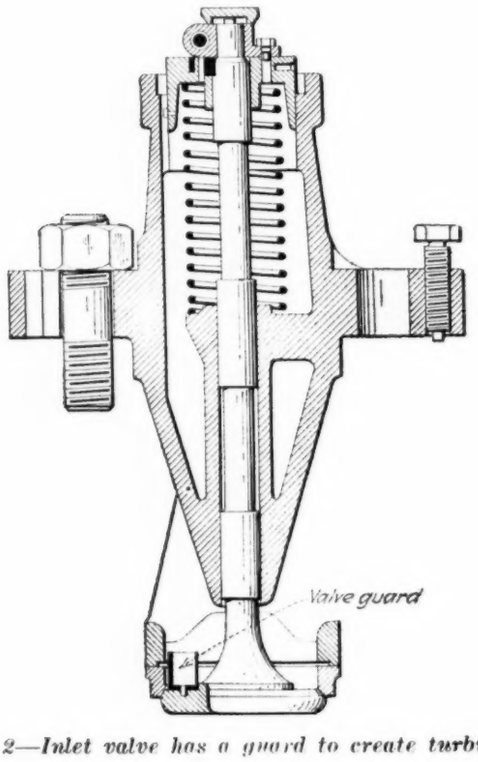


Fig. 2—Inlet valve has a guard to create turbulence

time of opening varies with the load. This is accomplished by the governor, which shifts the eccentrically mounted end of the bypass lever.

Why Governing Is Difficult

The difficulty in governing airless fuel-injection engines arises from the very small quantity of fuel handled per stroke. This is not so readily subdivided to meet the requirements of a variable load. The requisite quantity of fuel within the pump decreases with the size of the engine until a point is reached where the dimensions of the pump become so small that governing is no longer practically possible.

This condition is offset by making the pump from 1.4 to 1.5 times as large as would be required for maximum load, and diverting the surplus fuel back to the suction side. The procedure is the same as the previously described governing of the suction valve, which never remains entirely closed during operation, but remains open for a longer or a shorter time, as the load demands.

The former method has the advantage that the pump valves are left intact by the governor and consequently the valve operation remains unchanged. Another important advantage is the assured full discharge pressure which is obtained at every engine load.

Since the highest fuel economy of airless-injection engines is often obtained with high ignition pressures, the latter often border dangerously close to preignition when the governing mechanism varies the injection time and on full load admits oil considerably before dead center. This condition results in heavy engine stresses because the operation is inelastic and subjected to severe shock. Delayed ignition results in much lower pressures and a smoother operation of the engine, and for this reason F. Krupp adopted the design shown.

Tests on a 520-hp. Krupp engine gave the results shown in the table.

FUEL CONSUMPTION IN POUNDS

Load	¼	½	¾	Full	1.11
Fuel per i. hp.-hr., lb.	0.278	0.286	0.288	0.311	0.316
Fuel per b. hp.-hr., lb.	0.52	0.414	0.378	0.374	0.377

These results compare favorably with those obtained from other solid-injection engines and are fully equal to the performances of air-injection engines.

For some time airless fuel injection has been employed in engine cylinders rated between 400 and 500 hp., and the design becomes impossible only when a cylinder size is reached when, to prevent an increase in the maximum cylinder sizes, a single fuel valve is incapable of diffus-

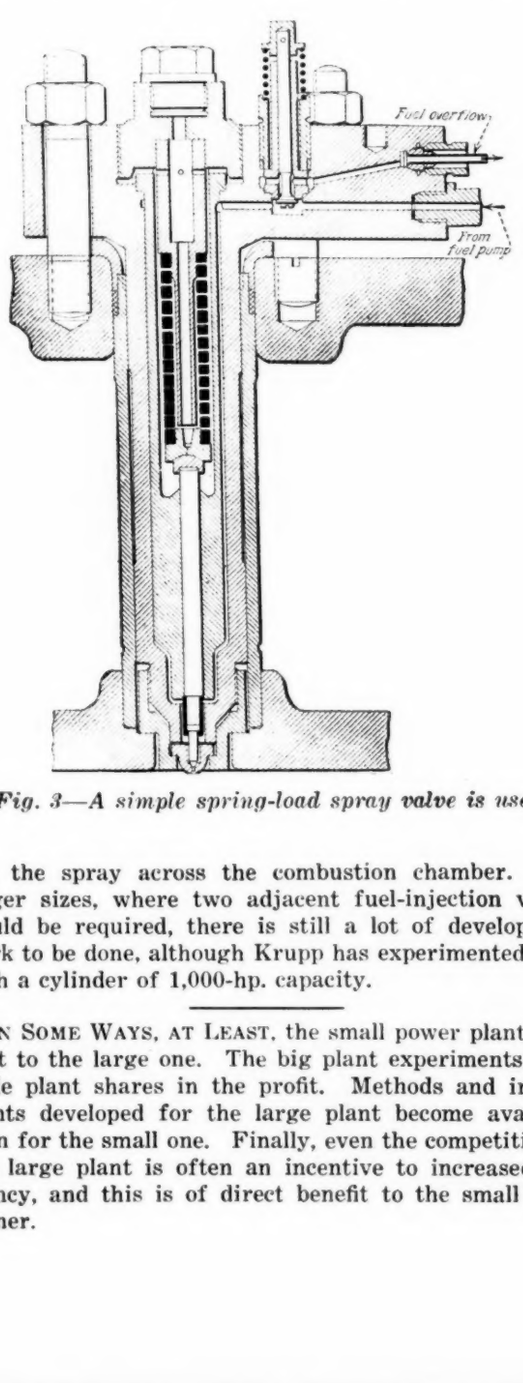


Fig. 3—A simple spring-load spray valve is used

ing the spray across the combustion chamber. For larger sizes, where two adjacent fuel-injection valves would be required, there is still a lot of development work to be done, although Krupp has experimented with such a cylinder of 1,000-hp. capacity.

In Some Ways, at Least, the small power plant is in debt to the large one. The big plant experiments; the little plant shares in the profit. Methods and instruments developed for the large plant become available soon for the small one. Finally, even the competition of the large plant is often an incentive to increased efficiency, and this is of direct benefit to the small plant owner.

Testing Gas Welds*

By Dr. H. D. Whittemore†

WHILE we wait, not without some impatience, for a non-destructive test for welds that is commercially practicable, we must content ourselves with the usual tensile and other laboratory tests. For a rough check on the quality of a weld the cold-bend test has proved valuable. I hope to see most welding shops use some simple testing machine that gives numerical results.

The Charpy impact machine meets this need very nicely. Leave off all gadgets and superfluous money-consuming refinements. Provide an anvil to support the specimen, uprights of any suitable rolled steel section, a pendulum of one-inch steel bar four inches wide swung on an axle at the top.

To make a test, swing the pendulum up until it rests against a stop just beyond the top center. Drop the specimen into place in the anvil. Push the pendulum over the center. Crack, goes the specimen! Record the energy absorbed by the specimen, by a maximum pointer on a graduated dial on the axle. Nothing could be simpler or less expensive.

Non-destructive Tests for Welds

This subject has received much consideration in the past. It presents great difficulties, and the best scientific and technical ability is needed if the problem is to be solved satisfactorily. Of the tests that have been considered, the following are three that have been proposed:

1. The Electrical Resistance Method—The electrical resistance across a weld can be accurately measured even when the weld is part of a structure, such as a steel ship. The difficulty is not in measuring the resistance, but in finding a relation between the resistance and the strength of the weld. Clean metallic surfaces that are in intimate contact have low electrical resistance but no tensile strength. This method does not seem to offer a solution of our problem.

2. Magnetic Analysis—Measurements of the magnetic flux in ferrous metals under a constant magnetizing force has all the requisites except one for a non-destructive test of welds. It is inexpensive, rapid, and can be used almost anywhere. The one exception that is most important is that it does not infallibly indicate defects that affect the strength of the joint. However, it errs on the safe side. This method is being used successfully to locate defects in steam-turbine bucket-wheel forgings. It is difficult, however, to see how it can be used on welds where the thickness and contour of the metal varies greatly, such for example, as on the fillet weld where an I-beam joins a column. The magnetic method is particularly suited to long pieces having a uniform cross-section.

Some experts in this field believe that magnetic analysis will eventually be successfully used to determine the quality of welds, but we must remember that the magnetic permeability of the material depends greatly upon the stress and still more upon the heat treatment to which it has been subjected. Most metals have had a reasonably uniform heat-treatment, so that this very disturbing influence does not make the detection of flaws impossible. When, however, it is used on unannealed welds, the variations in permeability caused by the welding process effectively mask the defects in the welds. If the welds are annealed after fabrication, some defects become apparent.

3. X-Ray Examination—The work that has been done on this method seems to show that many defects in welds can be detected, but the defects must be cavities in the metal either filled with gas or non-metallic inclusions or must be cracks or other discontinuities that are approximately parallel to the direction of the rays. The indications, fortunately, are not affected by the stress in the material or by variations in the heat treatment. At present it seems evident that more work should be done to perfect this method, as it is not affected by conditions that are unavoidable in welds. We may, therefore, expect within a few years that X-Ray examinations will be made commercially on important welds if the thickness does not exceed two or three inches. The cost, however, is high at present—five or ten dollars for each photographic record.

*Extracts from a paper presented at International Acetylene Association meeting, Chicago, Nov. 11, 1926.

†Bureau of Standards.

Determining Surface Areas of Pipes

By F. E. Matthews

Frequently, it becomes necessary to make quick computations involving pipe areas. Tables of dimensions of pipes are not always at hand and in any event they do not always contain the required data in the desired form. Such tables, to cite an extreme case, may not contain a column of superficial areas per foot of length, a most deplorable omission from the engineer's point of view.

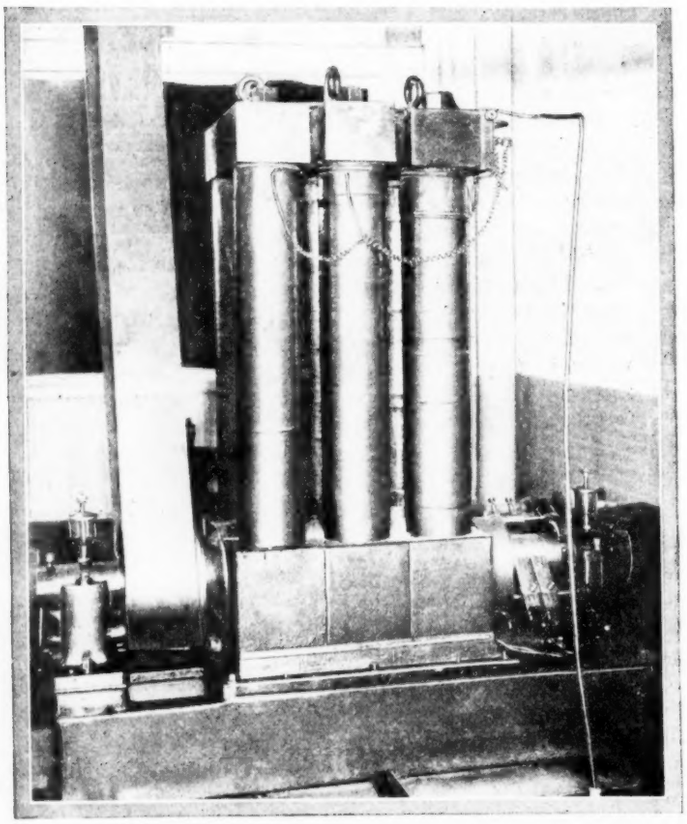
For men working with the subject continuously, it is easy to memorize the few areas most frequently encountered if the following rough rule is observed.

The basis of the rule is that the superficial surface of 7-in. pipe is two square feet per foot of length and that the surface for other sizes varies as the diameters. The rule would therefore be exact if *outside* diameters were used, but as a matter of fact it becomes slightly inaccurate because, to be of practical use, "nominal sizes" must be substituted for "actual outside diameters." The difference between these two values determines the amount of the inaccuracy of the rule.

As the superficial area of a 7-in. pipe is two square feet per foot of length an area-diameter ratio of $\frac{2}{7}$, or 0.2857 is established. To determine the approximate area for other sizes of pipe, it is only necessary to multiply this factor by the new nominal diameter or size of the pipe. For example: The area of a 7-in. pipe per foot would be $7 \times \frac{2}{7} = 2$ sq.ft.; that of a 12-in. pipe, $12 \times \frac{2}{7} = 3.43$ sq.ft., which, since the actual outside area is 3.34, is about 3 per cent too large. Below 7 in. the results given by the rule become increasingly too small, but do not become small enough to indicate the *inside* area until $\frac{3}{4}$-in. pipe is reached.

The rough rule, pipe area per foot $= \frac{2}{7} d$, in which d is the nominal pipe size, is therefore quite accurate for ordinary computations in which sizes near and above 7 in. are involved and less accurate for smaller sizes, the inaccuracy being less than the difference between the outside and the inside areas as long as the size is larger than $\frac{3}{4}$ in.

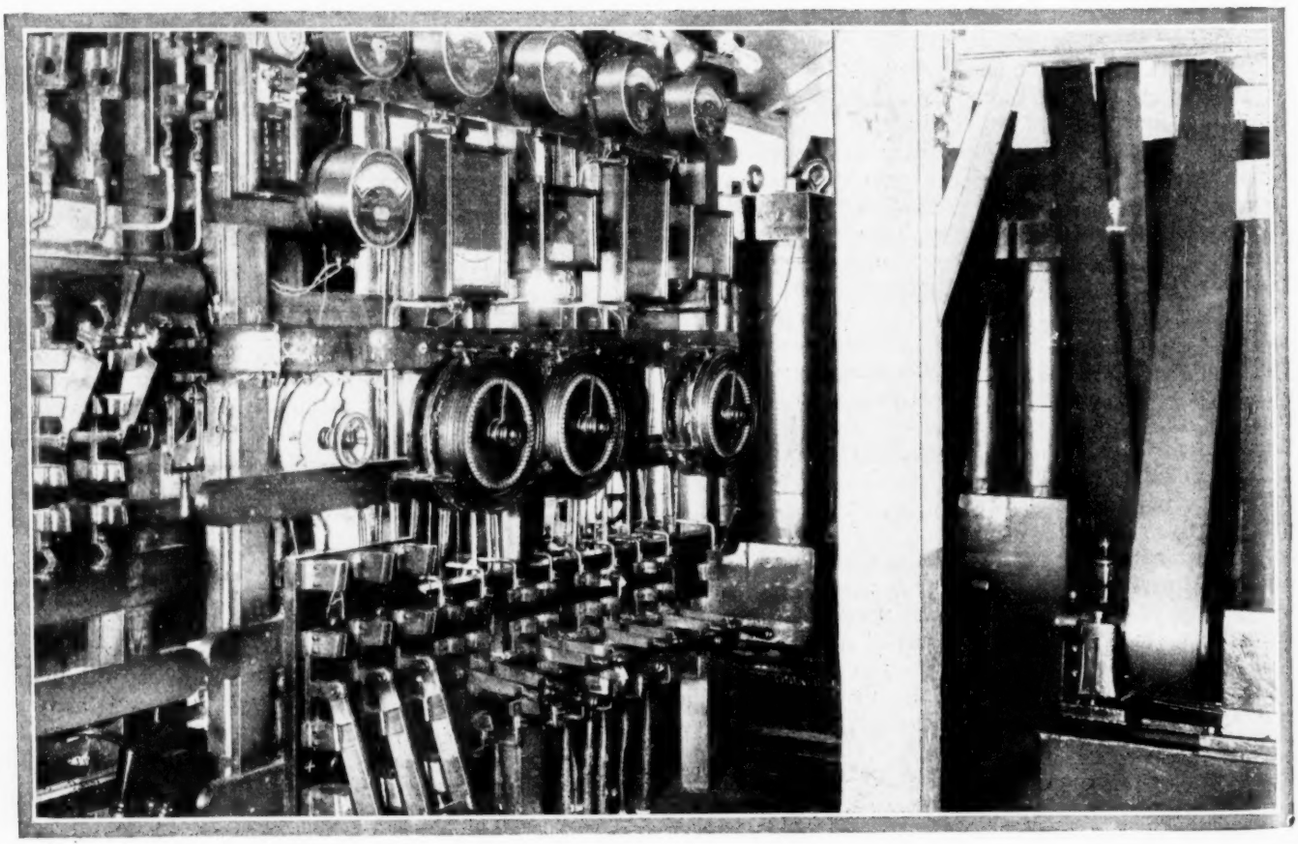
Old Dynamos Still Running in Historic New Bedford



Bipolar Machines Were Installed in 1882

Through moving pictures of whaling days the average citizen, East and West, has gained a romantic mental picture of old New Bedford in the days when this Massachusetts town was the center of the whale industry and the home port of as adventurous a bunch of salts as ever sailed the high seas.

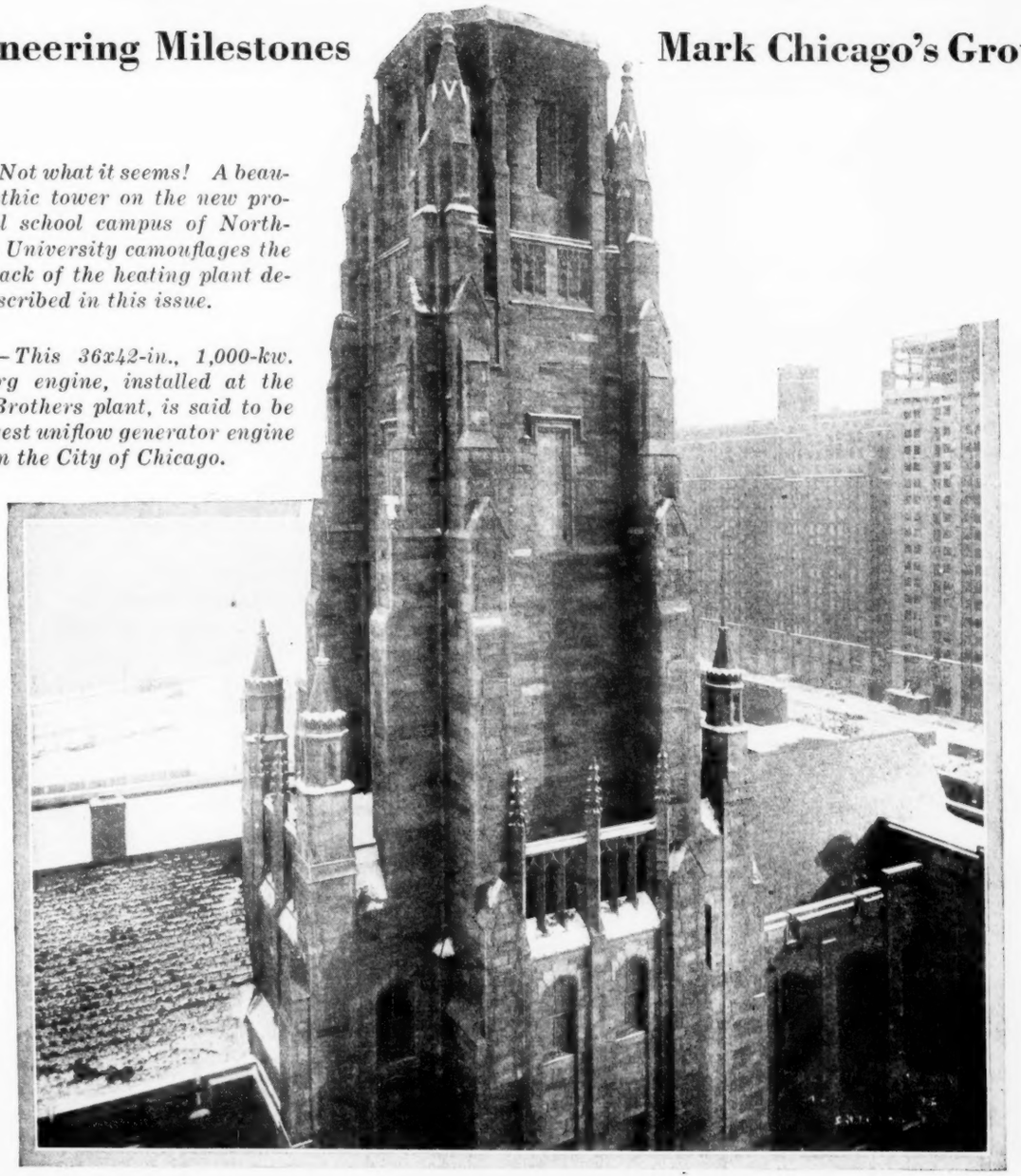
The palmy days of whaling have passed, but here is another touch of romance. Three direct-current generators, installed in 1882, are still operating in the plant of the Grinnell Manufacturing Corp. at New Bedford. These belt-driven bipolar machines were built by the old Edison Machine Works, which later became part of the General Electric Company. At the left is a close-up of one of the generators. Below may be seen the old switchboard, also installed in 1882.

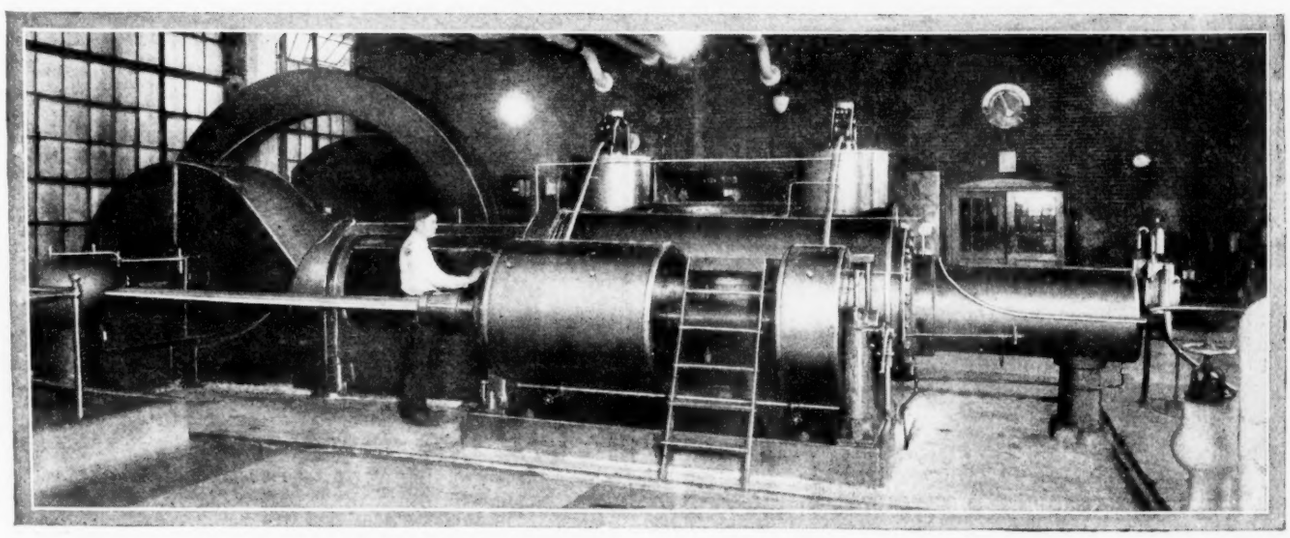


Engineering Milestones Mark Chicago's Growth

Right—Not what it seems! A beautiful Gothic tower on the new professional school campus of Northwestern University camouflages the smokestack of the heating plant described in this issue.

Below — This 36x42-in., 1,000-kw. Nordberg engine, installed at the Bunte Brothers plant, is said to be the largest uniflow generator engine in the City of Chicago.





How Synchronous Motors Are Started

By R. M. MATSON
Industrial Control Engineering Department,
General Electric Company

TYPES of starting equipment, methods of automatically connecting the field coils to the source of excitation and the protection that should be provided for the motor are among the subjects discussed in this article.

IN THE last few years there has been an increasing demand for improving the power factor of industrial loads in order to secure more economical power distribution. The worth of the synchronous motor, which provides a ready means for improving power factor, was quickly recognized in this respect. This immediately created a demand for substantial motors of this type and for suitable control equipment. At the present time control equipment for a synchronous motor may be classified as manual, automatic and semi-automatic. These

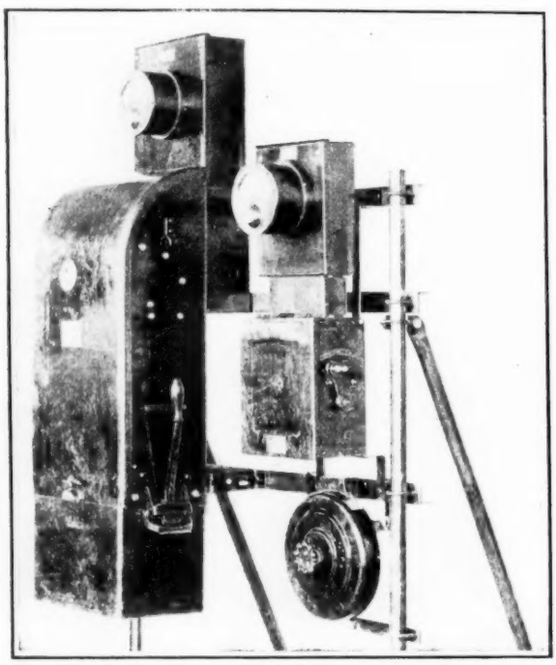


Fig. 1—Manual type reduced-voltage starter for synchronous motors

three types of control may be either reduced-voltage or full-voltage starters.

A typical reduced-voltage manual control is shown by Fig. 1. With this type of starter the proper time for each operation is left to the judgment of the operator. The motor is started by moving the handle of the compensator to the start position. As the motor accelerates on a reduced voltage, the operator determines the proper time to throw the compensator handle to the run position, usually connecting the motor to full line voltage, by the sound of the motor or observation of the line ammeter. Again, the operator determines by judgment the proper time to apply excitation to the field of the motor. This type of starter, therefore, requires a competent and skillful operator.

The full-voltage, automatic starter, Fig. 2, and the reduced-voltage starter, Fig. 3, are operated by push-button stations which may be at points remote from the starting equipment. With this type the operator merely presses a start button, which in turn controls the automatic starter. The exact time of each operation is governed by a suitable relay, which may be set properly when the equipment is first installed, and from that time on the starter will perform the operation each time the start button is pressed. This type of starter eliminates the need of a skillful operator since, after the equipment is once properly installed, a person with no knowledge of electrical machinery may start the motor successfully by pushing a button.

The semi-automatic starter, Fig. 4, is a compromise between the manual and the automatic starter. In using this type, the operator starts the motor on reduced voltage, then changes to full-voltage connections at the proper time. From this point the automatic part of the control panel comes into effect and applies excitation to the field of the motor at the proper time. When a full-voltage starter of this type is used, the change-over from reduced to full voltage is eliminated and the starting is comparatively simple.

Operation of Reduced-Voltage Starter

The operation of the reduced-voltage starter, Fig. 3, may be understood by referring to the simplified diagram in Fig. 5. Pushing the start button energizes the time relay through the tips of the overload relay *OL*, the stop button, the start button and then through the holding coil of the time relay to the line. At the time the holding coil is energized, contact *I* of the time relay closes. The closing of contact *I* forms a closed circuit around the start button, which will keep the time relay energized even though the start button is released.

At the same time that the holding coil is energized, the motor of the timing relay is energized through the contact T_2. Through this same contact the coil of the five-pole starting contactor *S* is also energized, causing contactor *S* to close. The closing of the starting contactor applies a reduced voltage to the terminals of the motor by means of the auto-transformer.

After a delay, which depends upon the setting of the time relay, the contacts T_2 open and contacts T_1 close. The opening of contacts T_2 de-energizes the starting contactor coil *S*, which allows the starting contactor *S* to open. As soon as the starting contactor opens, the coil of running contactor *R* is energized through the tips of the overload relay *OL*, the stop button, contact *I* of the time relay, contact T_1 of the time relay, the interlock *S* on the starting contactor and thence through coil *R* of the running contactor to line L_1.

The starting contactor *S* and the running contactor *R*

are interlocked mechanically and electrically, so that only one may be closed at a time. This is done in order to insure freedom from short-circuiting the lines L_1, L_2 and L_3 through the auto transformer coils, which would result from closing both contactors at the same time.

At the time the running contactor closes, the field relay contactor coil *FR* is energized from L_3 through the tips of the overload relay *OL*, the stop button, the contacts *I* and T_1 of the time relay, the starting contactor interlock *S*, and through the contactor coil *FR* to T_1 of the motor. Energizing the contactor coil *FR* of the field relay, Fig. 6, tends to close the interlock *FR'*. The immediate closing of interlock *FR'* is prevented by the retarding coil *R* of the field relay. The retarding coil *R* is connected in the discharge circuit of the motor field during the acceleration of the motor. As the motor accelerates, the induced field current through the retarding coil decreases, as shown in Fig. 7, and releases the interlock when the motor nears synchronism. After a short delay the interlock *FR'* closes, energizing the field contactor coil *F*, causing the field contactor tips F_1 and F_2 to close and tip F_3 to open. The closing of tips F_1 and F_2 applies excitation to the motor field, completing the starting operation, while the opening of tip F_3 opens the discharge circuit of the motor field.

If the stop button is pressed at any time, the control circuit is opened, de-energizing all contactor coils and causing the contactors to open. The opening of the tips of the overload relay *OL* causes the same action as does the pressing of the stop button.

The operation of the full-voltage starter, Fig. 2, is similar to that of the reduced-voltage starter described. For full-voltage starting, the auto-transformer, starting contactor and time relay are omitted. When the start button is pressed, the running contactor is energized and connects the motor to line voltage. From this point on the operation is the same as that of the reduced-voltage starter.

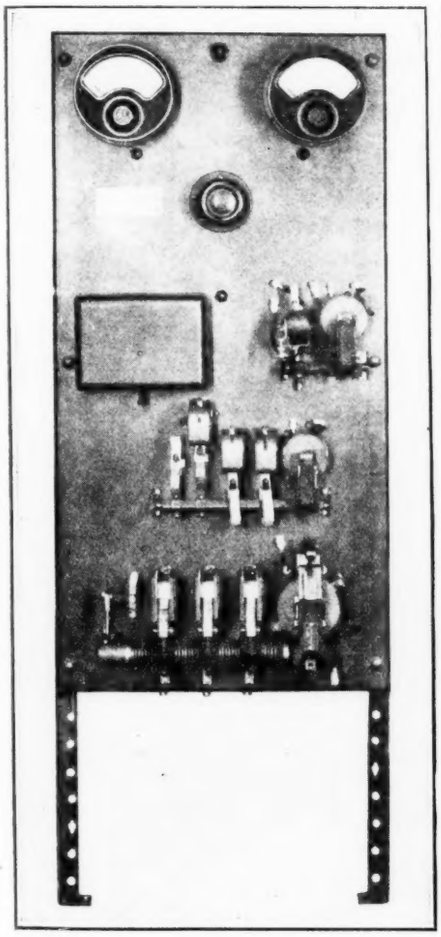


Fig. 2—Across-the-line type automatic starter

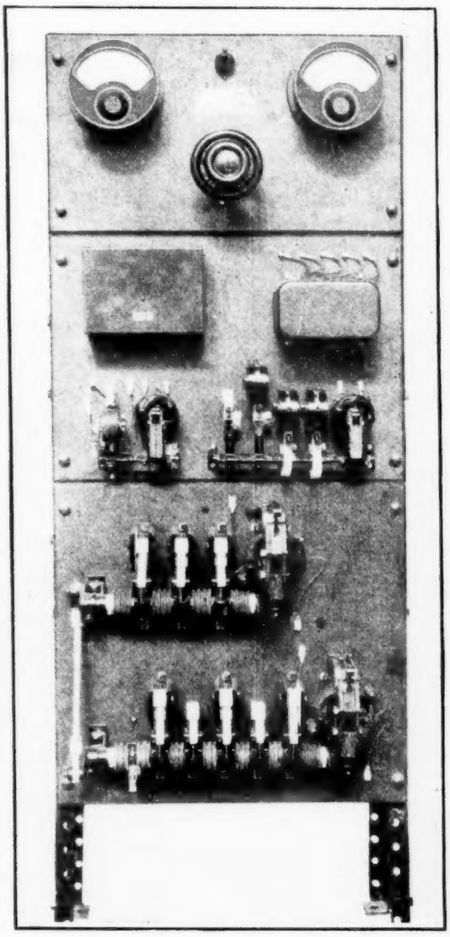


Fig. 3—Reduced-voltage type automatic starter

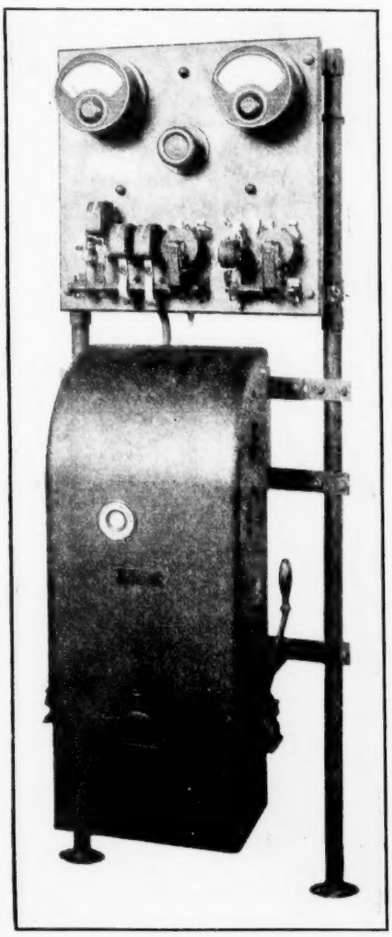


Fig. 4—Reduced-voltage semi-automatic starter

Methods of Applying Excitation

There are three commonly used methods of applying excitation or direct-current voltage to the synchronous motor:

1. By relays responding to decreasing frequency.
2. By relays responding to decreasing induced field current.
3. By definite-time relays.

One form of frequency relay consists of an armature carrying a normally closed contact which has a relay coil of high resistance and low inductance wired in parallel with a reactor of low resistance and high inductance. When voltage is applied to the motor, current induced in the motor field causes the frequency relay to

pick up since, because of the high inductance of the reactor, most of the current flows through the coil of the frequency relay. As the motor accelerates, the frequency of the induced field current drops, allowing the current to flow through the reactor coil, and the frequency relay drops out and causes field current to be applied to the motor.

This provides, under certain conditions, a good method of field application. It will, however, always be subject

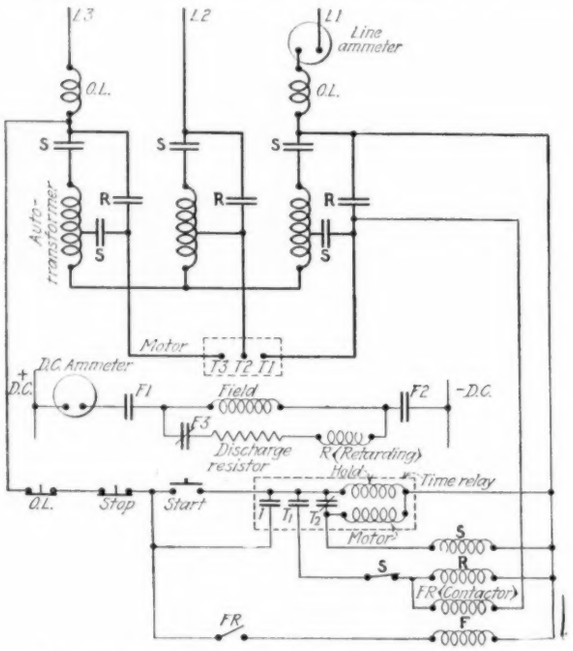


Fig. 5—Simplified diagram of reduced-voltage automatic starter

to one disadvantage: that is, the maximum speed to which a synchronous motor will accelerate without field varies with load, and this type of relay has to be set for a definite value of speed. Therefore, if the motor does not come up to the speed for which the relay is set, the field will not be applied and the motor will continue to run on its amortisseur winding. This relay must, therefore, be set for a low enough speed to meet adverse load conditions.

Induced-Field Relay

One form of induced-field relay is a double-throw device having both alternating-current and direct-current coils. The direct-current coil is connected to the source of excitation and the alternating-current coil is connected in the motor field circuit during starting. As the motor accelerates, the current in the alternating-current coil decreases until the direct-current coil exerts a greater force than the alternating-current coil, causing the contacts of the alternating-current coil to open and those of the direct-current coil to close. It will be readily seen that this is subject to the same disadvantage as is the frequency relay.

The relay used on the panels in Figs. 2, 3 and 4 responds to diminishing induced field current and consists of a contactor armature on which is mounted a magnetic time interlock. When full line voltage is applied to the motor, the contactor coil is energized, but the immediate closing of the interlock is prevented by a retarding coil in series with the motor field and energized by the current induced in the field winding. When the motor reaches a speed near synchronism, the field current decreases, allowing the interlock to close after a brief time delay, and applying full field. This time delay is not a predetermined value, but varies with the acceleration of the motor after the interlock is released. This provides a flexible means of field application as it allows the relay to be set to release at the highest speed to which the motor will accelerate under the worst conditions, but still allows a time delay in applying field so that, under normal conditions, the motor will reach a still higher speed before field is applied.

The definite-time relay consists of a separate relay which is not tied up with the speed of the motor in any manner. With this relay it is possible to set the predetermined time for applying the field at a value that is long enough to allow the motor to accelerate to its highest peak under all conditions.

The disadvantage of the definite-time relay is that, if the relay is set for a comparatively long time and the motor accelerates in less time than the period for which this relay is set, field will not be applied until the time for which the relay is set has elapsed.

In the average synchronous motor installation protection should be provided against overload, phase failure or single-phase operation, undervoltage, loss of field voltage and prolonged operation without starting.

Kinds of Protection

Ordinary overload includes any abnormal operating condition which may cause a flow of current as high as four or five times normal. Here the problem is to protect the motor against injury from overheating and at

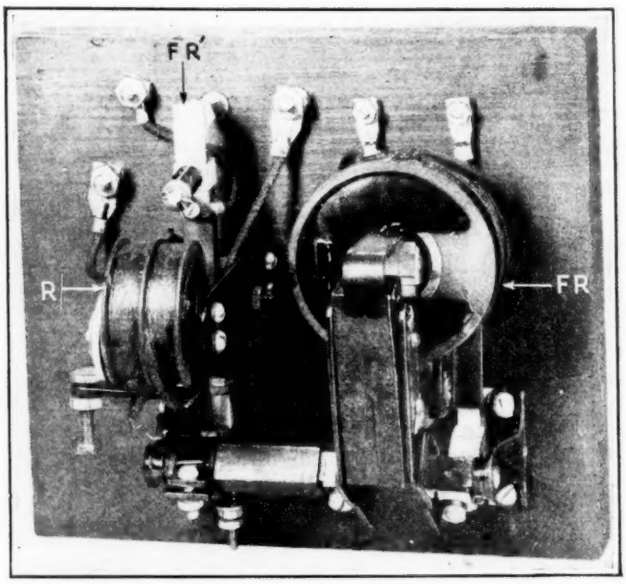


Fig. 6—Relay for applying field automatically to synchronous motors

the same time avoid shutting it down unless necessary to prevent damage to the windings. This involves the use of an overload relay which will follow as closely as possible the heating characteristics of the motor.

Two main types of overload relays are used for ordinary industrial service. The inverse-time type is set to trip at a definite sustained current, and will trip more rapidly as the overload increases. The action of this

type depends on the adjustment of the current coil which gives the tripping force, and on the setting of the time delay or inverse-time features. The thermal type carries a current proportional to the load current, and the time required for the relay to open depends on the rate at which heat is transferred from the heating element to the thermostatic element which trips the main switch.

The inverse-time relay is capable of slightly quicker action when under extreme overload, but the thermal type can be proportioned to follow more closely the characteristics of the motor itself with regard to the amount of heat it can absorb without overheating; that is, without tripping. The thermal relay has an advantage in its adaptability to meet starting conditions without having a high continuous-current setting, since it can be set for 100 per cent of the motor current and will usually carry the starting current of the motor without tripping.

With other types of relays the overload relay is sometimes short-circuited at starting. However, though the operator will probably be at hand to watch the starting of the machine, it is more desirable to have the relay in

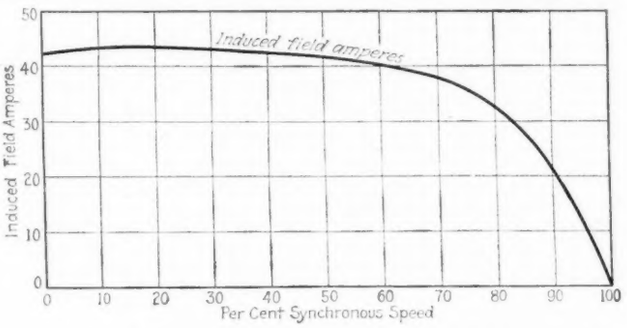


Fig. 7—Curves show how the induced field current varies during starting a synchronous motor

the circuit at all times. The starting of a motor generates a certain amount of heat in its windings, and this amount may be quite large in the case of motors starting heavy loads. A relay short-circuited during starting cannot allow for this heating.

Single- or open-phase protection of polyphase motors is usually left to the overload relay. A three-phase motor carrying a given load will draw 73 per cent more current in the remaining phase if one phase opens. If this increase in current represents an overload, a thermal relay will shut down the motor. If the motor is operating at reduced load, it is possible that no overheating will occur, and the open phase will then be evident by the failure of the motor to re-start after being shut down.

Undervoltage Protection

Undervoltage protection should always be included in a synchronous motor panel. Contactors operated from the alternating-current supply will automatically open on failure of voltage. After a drop in voltage sufficient to throw the motor out of synchronism, the return of full voltage will not enable the motor to accelerate to full speed and re-synchronize unless the pull-in torque of the starting winding is unusually high. With certain types of loads it is possible to remove the excitation and load when line voltage fails. Then, by providing a holding circuit which will continue after failure of voltage, the motor can be re-started without action on the part of the operator. However, it is not well to maintain this circuit indefinitely, since this would permit the motor to re-start after a prolonged voltage failure, unless the operator remembered to break the holding circuit.

Loss of Excitation Voltage

Loss of excitation voltage will cause the average slow-speed synchronous motor to stall if it is carrying nearly full load, since the starting winding will not develop enough torque to carry the load even temporarily. A high-speed motor, however, might continue to carry full load, and would operate as an induction motor with increased current and lagging power factor. However, the starting winding is not designed for continuous duty, and provision must be made to shut down the motor within a short time if excitation fails. Ordinarily, the increase in line current resulting from loss of field will trip the overload relay. But, if the character of the load is such that the motor may operate with light loads, the overload may not afford adequate protection. To meet this condition, panels are sometimes equipped with a direct-current undervoltage relay which will shut down the motor on failure of the excitation voltage.

In addition to its starting and protective functions, the synchronous-motor panel indicates to the operator the performance of the machine. Line and field ammeters are practically standard equipment on all synchronous-motor panels. The line ammeter gives a measure or an indication of the heating of the motor and provides an easy method of adjusting the field to give unity power factor, or minimum line current for any given load. The direct-current or field ammeter enables the operator to adjust the excitation current to the rated value given on the motor nameplate. Since under-excitation will reduce the maximum torque of the motor and cause it to operate at lagging power factor, and since over-excitation may overheat the field winding, it is important to have a means of easily adjusting the excitation to the correct value.

Stopping Cutting of an Elevator Worm and Gear

The absence of lubrication in the worm and gear of elevator machines, or using an improper quality of oil, may cause the worm and gear to cut. This action is made evident by a loud grinding noise in the gear case and heating of the worm and gear, accompanied in many cases with vibration of the machine. The grinding noise, however, should not be confused with that which occurs when a ball thrust bearing is in bad condition due to chipped balls or races. This fault was common with the ball-disk thrust bearing. One of the causes of this trouble was adjusting the thrust bearing too closely, which caused it to bind and chip the balls.

To stop cutting of a worm and gear, put about one pound of sulphur in the gear case with the oil and operate the machine until the gear teeth take on a smooth polished surface and the noise ceases. Under ordinary conditions this will require about eight hours' operation. If the elevator is used only intermittently, a longer period will be required. After the worm and gear are in condition, drain the oil from the gear case and wash it out with kerosene, being sure that the case is thoroughly cleaned out before putting in new oil.

Announcing Conditions for POWER *Prize Contest*

LAST week announcement was made of a prize contest carrying awards of $850 by *Power* for the articles showing the most commendable improvement in the results obtained from the modernization, reorganization or improved operation of a power plant, during the last two years.

1st Prize	**$500**
2d Prize	**250**
3d Prize	**100**

HERE ARE THE CONDITIONS OF THE CONTEST:

— 1 —

The manuscripts submitted will be judged on (a) the value of the results, not alone on savings in dollars, (b) ingenuity displayed, (c) general interest and applicability to other plants, (d) method of presentation.

— 2 —

The identity of the plant must be revealed in the text and the story must be subject to verification.

— 3 —

Articles should be as short as consistent with telling the facts; preferably not exceeding 4000 words exclusive of illustrations, which are desirable.

— 4 —

All manuscripts should be submitted by May 15, addressed to *Power*, Tenth Ave. at 36th St., New York, and plainly marked "Entered in Power Prize Contest". The manuscripts should not be signed but each should be accompanied by a letter of transmittal giving author's name and address. For the purpose of judging, such letters will be keyed to the manuscript and filed.

— 5 —

Articles which do not win prizes, but which possess sufficient merit to warrant publication, will be used subsequently and paid for at regular rates.

— 6 —

The competition is open to all without regard to position.

— 7 —

Names of the judges selected by the editors will be announced later.

Better Local Meetings

AT THE meeting of the Metropolitan Section, A.S.M.E., the other evening, five splendid papers were presented, with ample time for each author to give his paper practically in full, with lantern slides for all the illustrations, and for all who desired to discuss the papers to talk as long as they wished. Interest ran high, and everybody felt fully repaid for the time spent.

Contrast a session of the annual meeting of the Society. The author is allowed ten or fifteen minutes for abstracting what is in his paper. Discussion is similarly limited, and usually the session adjourns with the subject unfinished.

Accordingly, it was pleasant to hear one of the leaders in Society activities call attention to the desirability of extending the practice of presenting top notch papers before local section meetings. The schedules of the "big" meetings are too full—far to full. Those who attend are bewildered by the array, and not infrequently have to make the difficult choice between two meetings, both of which are of deep interest to them. The presentation of important papers before local sections, perhaps the same paper before several sections, is a step in the right direction. Discussion could be reported and published without difficulty.

The local sections of the A.S.M.E. have a lesson to learn in this respect, and so have local engineering societies and the local chapters of other engineering organizations. It is easy to assume that because a body is local, high-grade talent is not to be sought, and many a group of men worries along, holding periodic meetings because the calendar indicates certain dates, and spends its time in profitless talk. Now and then, however, somebody steps out and shows that the most capable men of the community can be induced to present the results of their study and work before their technical neighbors. It pays. The opportunity is before any worth-while organization of engineers. All that is needed is the nerve to do it.

Applying Excitation to Synchronous Motors

WITHIN the last few years the synchronous motor has been elevated from a position of doubtful consideration to one of confidence as a power unit for many industrial drives, in some of which it ranks over all other types of motors. The starting of these motors has always been a problem of first importance in their application. It is not alone getting the motor started and up to speed, but it must pull into synchronism and the excitation voltage must be applied to the field coils.

The earlier types of motors had poor starting torque and were not capable of starting under load. In some of these applications means were provided to bring the machine up to speed without load as a generator and synchronize it with the power source, after which the starting motor was cut out of service and the load applied by a clutch. Modern designs have largely eliminated this difficulty, and synchronous motors are available that will come up to speed and pull into synchronism under one hundred per cent full load, and will develop a considerably higher starting torque.

Methods of starting this type of motor have always been a moot question. It used to be general practice to start the motor on reduced voltage. This required three operations by the attendant, each of which depended upon his judgment as to how well it was done. Two of these operations, changing from reduced to full voltage on the stator windings and applying the excitation to the field coils, had marked influence on the line disturbance caused when starting. The use of automatic starters has to a large degree eliminated troubles that were present with manual-type starters, as is shown in the article, "How Synchronous Motors Are Started," in this issue.

Applying field to the motor is much like changing from reduced to full voltage on the stator; there is a point on the current cycle where this can be done with the least disturbance to the power system. So far none of the methods of applying the field to the motor takes this into consideration. It may be that the gain will not warrant the cost and complications, but there are conditions under which it would be particularly desirable to do this.

The Daily Check-Up

"EXPENDITURES for complete instrument equipment and for labor in planning economical operation and compiling detailed operating reports are often questioned as a doubtful investment. The cost of such work amounts to only a fraction of one per cent of the thermal efficiency of a large modern station, although the possible savings may easily reach several per cent in thermal efficiency."

This statement was made recently by H. M. Cook, test engineer for the Brooklyn Edison Company. As pointed out by Mr. Cook in the same talk, one of the outstanding features of the operating system used in the stations of the Brooklyn Edison Company is the preparation and study of daily reports covering the performance of important units such as turbines, condensers, boilers and air heaters.

Too often the computation and study of daily reports are delayed until much of their capacity for usefulness is lost. In the Brooklyn organization there is no unnecessary delay. The twenty-four-hour period ends at midnight, and it is then that three junior engineers start on their work, which includes changing recording charts, reading integrating dials, planimetering charts and averaging the data collected. These men also collect the daily coal samples and quarter them down for analysis. Before nine a.m. the data are ready for the

day force. With the aid of special charts and other aids to rapid work, all computations are finished and reports completed before noon. These charts also make it possible to turn much of the computation over to clerks, several of whom can work under the supervision of one engineer.

All of this would avail little if the reports were then filed away and the job called finished. Instead, there is a meeting each afternoon, attended by the station superintendent, chief engineer, first and second assistant chief engineers, chief boiler-room engineer and station test engineer. The test engineer, from his study of the data, is prepared to point out any falling off in efficiency. The operator, with yesterday's work still fresh in his mind, is generally able to put his finger on the trouble at once. In any case he soon finds it and corrects it.

The Brooklyn Edison Company has followed this practice for some time, with a steady improvement in the system coal rate. Smaller plants could not generally afford to go into such detail, but the principle of the daily check-up is so sound and practicable that most plants could adopt it, to some extent at least, with profit.

Radiation from Luminous Flames

AN INTERESTING paper on radiation from luminous flames was recently presented before a section of the American Chemical Society. This reviewed the literature on the subject, outlined the theory and gave the results of recent experiments on certain gases.

Previous investigations have indicated that the radiations emitted by non-luminous flames are due largely to energy waves set up at the instant of chemical combination by carbon dioxide and by the water formed from the combustion of hydrogen. Tests by the authors indicate that such radiations from methane, ethylene and acetylene, when burned with a non-luminous flame, averaged only about seven per cent of the total heat of combustion. Furthermore, experiments seem to indicate that these radiations are to a large extent independent of flame temperature. The authors make no attempt to analyze the radiations that are known to be emitted by heated carbon dioxide and water vapor. More data are needed on the nature and magnitude of such radiations.

When gases are burned with a luminous flame, combustion appears to take place by stages. In the first stage the hydrogen unites with oxygen, setting free the combined carbon in the form of incandescent particles The increased radiation from a luminous flame is therefore probably due to the radiation of such carbon particles. Obviously, these small black bodies are excellent radiators, and their emissions will vary approximately as the fourth power of the flame temperature, especially when the flame is of sufficient depth so that the projected area of the carbon particles will form a continuous surface.

The tests conducted by the authors indicated that radiation from a truly luminous flame is at least twenty-five to thirty per cent of the total heat of the gas. This is roughly four times the radiation from the same gases if burned with a non-luminous flame. The tests also indicated that hydrocarbons high in carbon, such as acetylene, gave more luminous flames than those relatively low in carbon and hence were greater radiators. Since the luminosity of the flame is a factor of the air admission and mixture, these factors are of importance in planning gas-fired furnaces where absorption by radiant heat will be an important factor. It would seem that pre-mixed air and gas to produce non-luminous flames may not be the most effective means of heating in many industrial furnaces.

It has been suggested that furnace operation might be improved by injecting soot or other carbonaceous particles into the gas to increase the luminosity of the flame. The authors of this paper appear to favor this idea. This condition is secured by the use of powdered bituminous coal where the material supplied furnishes the gaseous and also the carbonaceous elements to the furnace regardless of pre-mixing. It would therefore appear to be a logical deduction that the greatest emissions of radiant heat may be expected from such powdered-coal flames when burned under proper conditions of air supply and admixture. One cannot say, however, whether these desirable ends will be secured best by a long flame path or by pre-mixing with preheated air and violent turbulence. Experience seems to favor the latter, as higher flame temperatures are secured and the rate of heat emission by radiation is thereby increased.

Better Steel Castings

STEEL castings are expensive. When a foundry must make a hundred castings to produce twenty or thirty finished pieces, the waste is serious, not only in the foundry, but also in the machine shop, for defects are often not discovered until the casting has been partly machined. The time lost is frequently serious for the purchaser who must wait for a new casting.

An obvious remedy for this situation is the improvement of foundry practice, and to this end intensive efforts are being made by many steel founders. Definite progress has resulted. Some foundries have already reached a fairly satisfactory record. Others are following as fast as facilities permit. None is perfect.

Meanwhile the improvement of inspection methods will effect considerable saving in the machine shop. There are two methods that have been used with some success for discovering defects in rough castings. In certain cases the study of the magnetic properties of the casting is effective, in other cases the X-ray provides an excellent means of inspection. Unfortunately, both these methods are expensive and slow. However, as the demand for steel castings grows, as it must, progress will doubtless be made toward reducing the cost of inspection in the rough, and this will do much to reduce the cost of machining castings that are subsequently scrapped. For example, the organization of X-ray inspection to handle quantity production seems to be a promising field for reducing the cost of inspection and producing a more uniformly dependable product.

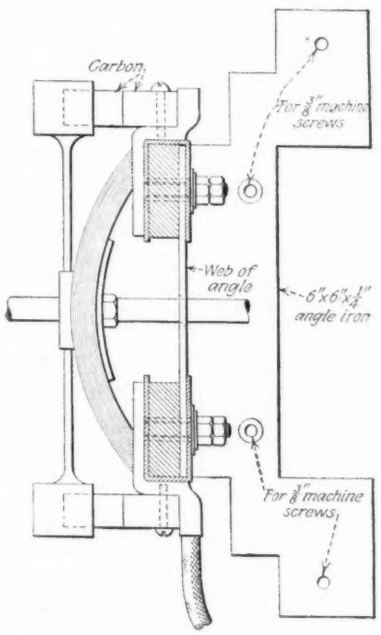
With rising steam pressure and temperature this is a problem of vital interest to the power-plant engineer. Anything that will make steel castings more readily available will assist the small plant in taking advantage of the improved economies achieved in the larger plants.

Pending that happy outcome, the power-plant engineer must not complain too bitterly over the high cost of steel castings. The equipment manufacturer is doing all he can to improve the situation, and he is making real progress, although it sometimes may appear to be a bit slow.

Ideas From Practical Men

Readers are urged to use this department for the exchange of practical operating information. A minimum of five dollars will be paid for contributions accepted

Repairing a Resistance Starter



Contact mounted on angle iron

Trouble with a contact caused the overheating of a three-phase 40-hp. slip-ring motor driving an air compressor, through a single-reduction herringbone gear. The rotor circuit was rated at 258 volts and 71.5 amperes per terminal. A governor closed two phases of the motor primary when the pressure declined to a predetermined value and the motor started with all resistance in the secondary. This resistance consisted of three carbon piles, and the pressure on the carbon cylinders was increased by a ratchet operated by the crankshaft, and then the resistance was shorted out by two laminated-copper contacts, the make-and-break being made by carbon contacts.

The trouble was first noted by the motor becoming unusually hot, which was strange, as the intermittent service was not severe. A split-type current transformer was clamped over one motor lead and the reading taken by an ammeter specially calibrated with the current transformer. The reading on one motor lead was 75 amperes, and on the other leads it was about 60 amperes. A check was first made of the governor switch and primary oil switch for loose connections, but none was found. Passing on to the secondary circuit, the slip rings were examined as were the brushes and leads. Upon looking over the resistances, one was noticed to be hotter than the others, but when the stationary contacts were examined, a slight crack was noticed in a cast-iron plate which extended from the controller frame. The compressor was started up and by looking at the contacts it could be seen that a gap of less than one-sixteenth inch existed between one set of the contacts and slightly more than this between the auxiliary contacts. This caused an unbalance of the rotor currents due to the current from one ring passing through the rather high resistance. This unbalanced the primary current of the motor and caused part of the winding to overheat.

The break was caused by the auxiliary contact becoming wedged in the holder, and as the ratchet pushed the moving element up, the strain broke the thin cast-iron section by bending it near the edge. To make the repair, all contacts and insulation were removed from the broken part and the remaining projecting portion of the casting was chipped smooth to the vertical frame plate. A piece of 6x6x½-in. angle iron of the proper length was secured and was sawed out by means of a hacksaw to the shape shown in the figure. Four ⅜x1½-in. machine screws were used to secure the angle iron in place of the cast-iron plate. Two countersunk screws were put in from one side and two hexagon-head screws from the other side, the angle iron being tapped twice and the cast-iron frame twice. The contact plate was drilled to take the contacts and insulation as shown in the figure. No mechanical difficulties were involved, and a strong substantial job was secured and the repair could hardly be seen after the contacts were mounted. The work was done by a mechanic and helper in about twelve hours. A complete new frame would have cost about $30 and required weeks to obtain.

Alcoa, Tenn. J. ELMER HOUSLEY.

Oil Pump for Gas-Engine Main Bearings

The accompanying photograph and sketch show how we have obtained more satisfactory results in supplying oil to the main bearings of seven vertical gas engines with small pumps rather than the usual way of supplying oil from individual oil cups.

A small two-plunger pump ¾-in. pipe size is mounted on a plate clamped under the nut of a corner anchor bolt. The pump is operated from a small disk on the end of the cross-shaft. A large reservoir was made for

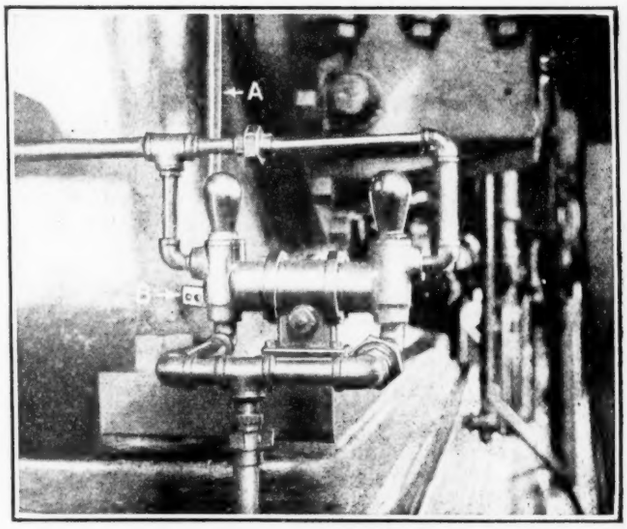


Fig. 1—Pump mounted on corner of engine base

each engine by welding heads into an 8-ft. section of 8-in. pipe. The drain line from the crankcase of the engine was connected to the reservoir which received the oil from about the middle of the crankcase supply. The suction line to the pump was taken from near the bottom of the reservoir at one end. The discharge line was run to a cross above the crankcase, and from the cross two lines were run, one to each main bearing. The fourth line was extended up to a small expansion and overflow tank mounted at the top of the cylinders. This tank was made from a 3x12-in. pipe nipple with

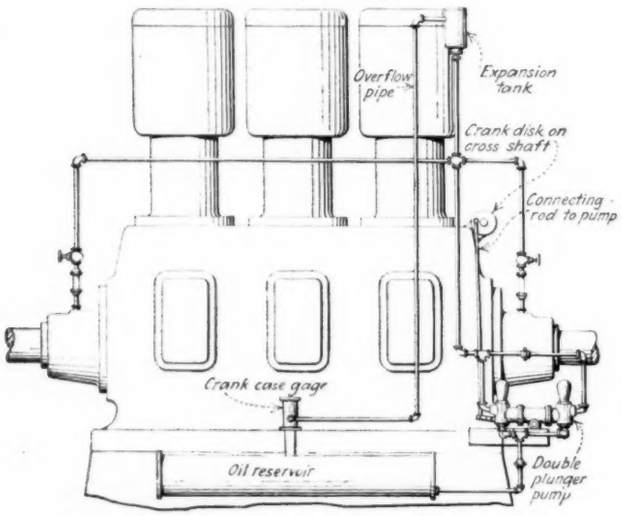


Fig. 2—Arrangement of pump drive and pipe connections

a 3x¾-in. reducing coupling at the bottom and a pipe cap on the top. This tank was tapped for a ¾-in. pipe connection about 3 in. from the top, from which the overflow line was run to the reservoir at the base of the engine. The overflow tank, being mounted on the top of the engine, gives about a 6-ft. head pressure on the oil flowing into the main bearings. The regulating valves in the lines to the bearings are kept adjusted to admit all the oil that the grooves in the bearings will pass. This keeps the bearings thoroughly flushed with oil. Each bearing pipe is fitted with a sight-feed glass to show the amount of oil flowing to the bearings. If the normal stream of oil begins to fill the glass and has to be cut down, it is an indication that the oil grooves are becoming clogged up.

Sewickley, Pa. L. M. JOHNSON.

Firing by Mathematics

The following plan of "firing by mathematics" was adopted in a plant with beneficial results. The plant had two return-tubular boilers with 27.5 sq.ft. of grate surface each and a water-tube boiler of 56.25 sq.ft. of grate surface. The latter was easily the most efficient, having a furnace 7 ft. high, while the other had but 28 in. furnace height.

I was told by the engineer that they burned 2,000 lb. of coal an hour and the evaporation was around 8.5 lb. They were in the habit of carrying heavy fires, using four 300-lb. wheelbarrow loads of coal at each firing, the helper wheeling in this amount directly after each firing, as there was little room for storage. I said to the engineer that he should have a stoker under the large unit and carry all the load with it. "First cost too great," he said; "they would never consider it." "Well, you fire about 1,200 lb. of coal at a time," I told him. "Now you burn around 33 lb. of coal a minute and a stoker would feed at this rate. Why don't you apply that principle to hand firing and fire two scoops of coal a minute? Also force your best boiler and check the draft on the other two."

He tried it and closed the hand damper tight on No. 1 boiler. The steam pressure was maintained without difficulty, and after a while the damper of No. 2 was closed. Two scoops of coal were fired at a time, and the result was that a thin white-hot fire was carried in No. 3, giving smokeless combustion. I returned to the plant two days later to see if the plan was still adhered to, and found the water-tube boiler carrying all the load with No. 1 cut out and a banked fire in No. 2. The fire in No. 3 became dirty in about six hours, and during the cleaning period the fire on No. 2 was forced about an hour. No. 3 was the only boiler equipped with dumping grates.

The engineer was enthusiastic about the results. The evaporation increased considerably, and as No. 3 boiler had a superheater, the steam going to the engine was at a much higher temperature, since all steam was now superheated 100 deg. Apart from increased evaporation the total steam flow was reduced by over 1,000 lb. per hour, and with a reduced flow of water through the heater much higher feed temperature was attained, the amount of exhaust steam available for feed heating being practically constant.

As the fireman had other duties, such as oiler, pumpman, etc., the plan of firing at one-minute intervals was modified to some extent after a few days. It was found that as high as 50 lb. of coal could be fired at a time without affecting the evaporation, lengthening the firing interval in proportion. The engineer assigned a repairman for one hour's duty in the boiler room to relieve the fireman for an hour in the middle of his watch to break up the monotony of such close attention to the fires. A. F. SHEEHAN.

Springfield, Mass.

Why the Motor Stopped When Being Blown Out with Compressed Air

In our plant the forced draft for the boilers is supplied by a 50-hp. motor-driven fan in the basement. As the motor has to operate in a dust-laden atmosphere, owing to the handling of coal and ashes, it has been our practice to blow it out about once a week with compressed air, this being done generally with the motor running. About a month ago our electrical maintenance man, who usually did this work, had just turned the air on the motor, when to his surprise the motor suddenly stopped and was found to be wedged so tightly that the rotor could not be turned over by hand. When the motor was apart, the cause of the trouble was apparent. The bearing had at some time been filled too full of oil, and the oil had run out the end of the bearings and been drawn into the motor and deposited on the face of the stator.

When attempt was made to blow out the machine, the ash dust which had lodged on the stator coils had been blown into the air gap and had combined with the oil to form a sticky matter and cause sufficient drag on the rotor to throw the circuit breaker.

Boston, Mass. C. L. ALLISON.

Comments from Readers

Asks for Report of Experiences with Zeolite

I am thinking of installing a Zeolite water-softening plant that I may have pure makeup water for my boilers, and would like to hear from some of the readers of *Power* who are using this type of softener, as to the results they are getting and if they are having any trouble from caustic embrittlement, or any trouble whatever from the use of this type of softener.

Henderson, N. Y. JOHN MACONNELL.

Estimating the Blowdown

Referring to the article, "Estimating the Blowdown," by R. D. Jenkins in the Oct. 26, 1926, issue, I believe this method is applicable to boilers having manually controlled feed-water valves that are closed when the boiler is blown, but misleading when used for boilers equipped with automatic feedwater regulators. The reason for this is evident, for when the blowoff valves are opened and the water level drops, the automatic regulator starts feeding water to the drums and the actual water-level drop, due to blowing down the boiler, is greater than shown on the gage glass. Hence the estimated pounds of water blown will be less than the actual amount.

I would greatly appreciate suggestions for estimating blowdown accurately under the foregoing conditions.

J. C. BOOSER,

Reading, Pa. Metropolitan Edison Co.

Cracks in Plastic Refractory Furnace Lining

That the crushing of old firebrick bats and using the material over again by mixing the gannister with a bonding cement is good practice, is generally admitted. It is even considered good to buy prepared plastic refractory for furnace lining. The work is monolithic, or is supposed to be so, and is easily installed.

A serious difficulty, however, with many of the bonding cements and plastic refractories, is that they shrink in drying and develop cracks. This does not mean that the refractory is poor material and is not a reflection on the refractory, or heat withstanding, quality of the material. This tendency to shrink in drying is found in high-priced as well as low-priced material.

The dealers in such refractories will tell us that these cracks are but superficial and that it is only necessary to plug them and the wall will be solid again. A little study will convince anyone that such is not the case and that the cracks are more than superficial and that the work cannot therefore be really monolithic.

Assume that a quantity of such material has been laid up in a wall 8 in. thick. If the brickwork against which it is built is hot, as from an adjacent furnace, the drying and cracking will begin at the back; and as the crack develops as the drying proceeds, it is obvious that when the drying is completed the crack must extend through to the face of the wall. If the brickwork is cold, not so much drying will take place at the back. Cracking is bound to take place on the face whether from natural drying or from a drying fire. If the face cracks run into a crack at the back, we have a broken wall. If they do not run into cracks from the back, we have at least a weakened wall. If we plug the face cracks, the wall will appear solid until the lining is worn away to the depth of the plugging, and then we have exposed edges that hasten wear.

While I have never measured the amount of shrinkage, I believe that in some cases it is as high as one per cent. This makes a serious mess of the wall and is annoying to those responsible for the furnace maintenance. R. MCLAREN.

Toronto, Ont., Canada.

The Derelict Engineer

I read with interest the contribution of A. Searles, in the Dec. 28, 1926, issue, on "The Derelict Engineer." This I consider an excellent portrayal of the engineer's position today practically the world over. Few companies want the elderly engineer whether he is seeking to improve his position, or unemployed and prepared to accept almost anything. This is partly our own fault. "Youth must be served" is the spirit of the age, and the older engineers fail to recognize this and do little to aid, consequently they neither sow nor reap and in time lose their means of a livelihood.

The Editor in his Foreword, "Because It Is Done," of the same issue hits the high spot, and because it is not fashionable today to employ elderly engineers, "it isn't done" and this alone accounts for many being without work.

It is difficult to locate the cause, but from a long experience I think we must accept some of the blame in so far that, through a mistaken notion of our own importance or for some other reason, we present to the youth of today (particularly those in power engineering) an attitude of stand-offishness and in many ways are difficult to manage or get along with—the opposite attitude of "Henry Clay" referred to in the editorial, page 954, Dec. 21, 1926, issue. I have in mind an old engineer of my acquaintance who was employed for many years with one firm. The proprietor (a few years older than he) and this engineer got on wonderfully well together, and this proprietor's last words to his son when on his death-bed were, "Promise me you will look after my old employees."

This promise was gladly made and intended to be faithfully kept, but on taking over control the son got no assistance from the engineer, but rather the reverse, and anything he wanted to know the engineer made it plain he would not get it from him and he could seek elsewhere. But it was the engineer who had to "seek elsewhere" and make room for someone who could and would give information. This old engineer is the only

veteran of that firm who is not still there or drawing a pension.

To treat the younger generation with slight respect is a common fault with elderly men, but engineers seem to possess an overdose, and not only keep everything to themselves, but also avoid as much as possible contact with other men both young and old. In my early days I received much valuable advice from a canny old Scotch engineer, and a little of this may be of interest to those engineers who think they are approaching the derelict stage and dread the future. This old-timer impressed upon me the fact that "no competent man ever got fired for being too young." Consequently, in gathering all the knowledge you can and doing your work, always endeavor to be the "baby" of the establishment, particularly when any worry or trouble is going about—just leave it to the "grown-ups"—and you are sure of your job to the last man. There is no dismissal; "it isn't done." No matter what your "vintage" may be, a trial of this will, I think, prove its value. I have never known it to fail.

Belfast, Ireland. F. P. TERRY.

Steam-jet Ash Conveyors

The article by C. G. Alexander in the Oct. 19, 1926, issue and my reply to it in the Nov. 16 issue, have evidently evoked interest in this subject. Thus the opinions of S. Brooks in the Jan. 4 issue are welcome as a means for exchanging ideas to the possible benefit of those interested.

All of us seem to agree that the past handicaps of steam-jet conveyors are as follows: (1) Excessive steam consumption; (2) frequently required replacement of wear-resisting liners and even worn pipe; (3) dust and noise attending the operation; (4) difficulty in freely discharging ashes from tanks, especially in freezing weather.

Let us carefully analyze these four causes and try to arrive at their possible elimination through means that can be incorporated as practical in the design and construction of both conveyors and tanks.

1. The induction-type steam-jet conveyor, as contrasted to the all-suction type "vacuum conveyor," is fundamentally a siphon of exaggerated dimensions. This device is expected to be airtight between its two open ends, with the steam entering at an intermediate point. Consequently, a steam-jet conveyor that is not permanently airtight becomes a poor application of the siphon idea as to efficiency. The shortest steam-jet conveyor with which I am familiar offered about ten chances of potential leakage, which included both the flange joints and the ash-intake openings with their closure plugs. The longest conveyor to my knowledge had about 70 such potentialities. Just think of the possible range of reduced efficiency between a condition of all joints permanently tight and on the other hand with some or all joints leaking, and it will become evident that the greatest single item affecting steam consumption is the condition of the joints.

Owing to the abrasive action of the ashes, castings used in these conveyors are expected to be hard, which makes them more brittle than ordinary machine castings. When erected into an all-over length of possibly 200 ft. or more, such a conveyor is subjected to vibrations due to surrounding buildings, equipment or incidental causes. In addition there exists reaction to steam of high temperature suddenly injected into the cold conveyor. For this reason one of the early designers rested the horizontal sections on rollers with occasional expansion joints between them. However, the roughness of the castings and their unbalanced position defeated his object, and some of the pipe sections, when later removed, were found cracked or broken, which meant that in time with the same size of nozzle the capacity of the conveyor decreased and thus it became more and more inefficient.

The lesson of this experience was that steam-jet conveyors should not have rigid joints, while they still have to remain airtight, in spite of the fact that the component castings are too hard to permit machining their faces at the joints. This is manifestly quite a problem, which, however, has been solved satisfactorily.

The next step toward increased efficiency is the best design of the steam nozzle with a view to smallest throat area and greatest possible expansion of steam. The efficiency of turbine nozzles in the last decade has been increased at least 10 per cent. Logically, this ratio should exist in steam nozzles used in these conveyors, even though, because of physical limitations within the conveyor proper, the best designs of turbine nozzles cannot be fully utilized.

The third consideration is the best general arrangement of the individual conveyor with a view to ample and unobstructed expansion of the steam injected for fullest utilization of its thermodynamical energy.

2. It goes without argument that the harder the liners the longer they will resist the abrasive action. It is logical, therefore, that since the inception of steam-jet conveyors the hardest castings were sought for liners either through a suitable composition or more frequently though a chill applied to their inner surfaces. However, figuratively speaking, the chill was only skin deep, and as this limited depth wore off, the resistance of the liners to wear became less effective. Were it possible to fashion liners entirely from carborundum or similarly hard material, the problem of wear would be well nigh solved. To mold them from crushed grains of carborundum or the like would defeat their object, as the binding substance would become the criterion of hardness in the entire liner. It seems, therefore, logical to cast pieces of carborundum into the inner surface of the liners, so that the wear of the combined surface is greatly prolonged.

3. Cut down the amount of steam, and the generating cause of dust and noise will be reduced likewise. With the exhaust properly vented a joint-tight and efficient conveyor should not be objectionably noisy. Dust should be allayed through a minimum quantity of water, which can be turned on automaticaly if desired. Baffles within the tank or vent are objectionable, because they create a back pressure and reduce the efficiency of the steam jet. If not watched closely, dust will accumulate on such baffles to further disadvantage. As against this the siphon action of the properly located spray nozzle will assist the efficiency of the steam jet. Thus irrespective of the plausible disadvantage of added moisture in the tank, the steam consumption must be reduced not only for the benefit of the operating efficiency, but also as a means for eliminating noise and dust.

4. With a properly designed tank there should be no apprehension over moist or wet ashes even in freezing weather. Since the moisture in the tank contributed by the spray is necessary for reasons already stated.

it is desirable to use tanks that will cope with this condition.[1] Naturally, steel-plate tanks are not advisable for wet ashes. Cast iron or even concrete tanks are better. However, in any case there should be no sharp corners within the tank, such as would form in the hopper bottom of a rectangular design. The forces parallel to the sides of such pyramid, together with the acute valley-corners between these sides, will readily cause arching over the bottom gate even in case of dry ashes. A similar condition obtains in case of side discharge tanks, although the component forces—one of them vertical and the other usually at 45 deg.—combine into a more favorable resultant. However, in either case for satisfactory discharge agitators should be used from the outside and located most judiciously within the tank.

The idea of steam coils in the bottom or the side of the tank for thawing out frozen ashes is in my opinion absurd and totally ineffective. If perforated to permit contact between steam and ashes, the holes would be clogged and out of commission in a short time. If not perforated the conduction of the heat to the frozen ashes would be slow and the wastage of steam exorbitant. The logical method is to inject live steam from hollow portions in the bottom of the tank through slots that are protected from clogging. When the tank is to be emptied, it will take only a few minutes to thaw out the bottom of the hopper, which is bound to collect most of the moisture and which is the narrowest portion of the tank and so most susceptible to freezing. Thereafter the agitators should be brought into play also in the upper strata of the tank, which are naturally easier to disturb.

While the foregoing suggestions have been applied with complete success in a number of cases, there are still opportunities for improvements like in any other branch of engineering. For this reason further contributions of ideas would be welcome, I am sure.

Philadelphia, Pa. EUGENE HAHN,
Hahn Engineering Co.

[1] Incidentally, moist ashes discharged from the tank will not create a cloud of dust.

Why Is the Vacuum Low?

In the Nov. 16, 1926, issue, A. W. Napier asked why the vacuum is low on a certain unit, giving readings on various gages and thermometers. In a well-designed condenser and with a tight system, the following approximate temperatures will be observed.

1 The difference of hotwell temperature and the temperature corresponding to the actual vacuum should not be more than 3 or 4 deg. F. A larger difference indicates air leaks.

2. The temperature difference between the average temperature of the cooling water (for example, ingoing water 60 deg. F., outgoing water 80 deg., average 70 deg.) and the hotwell temperature is generally about 20 deg. In this case hotwell = 70 + 20 = 90 deg.

3. The effect of air leaks on vacuum is best shown by a concrete example. Assuming, due to air leaks, that there is 7 deg. temperature difference between the theoretical vacuum temperature and the hotwell temperature; also that the amount of cooling water pumped is such as to give 20 deg. rise in temperature. Assuming further that the temperature difference between hotwell and average cooling water temperature is 20 deg. F. The following table will then show the vacuum obtainable with different temperatures of cooling water:

Vacuum obtainable, in.	25	26	27	28	29
Corresponding temp. from steam table, deg. F.	134	126	115	101	80
Hotwell temperature, deg. F.	127	119	108	94	73
Temp. cooling water discharge, deg. F.	117	109	98	84	63
Temp. cooling water inlet, deg. F.	97	89	78	64	43
Aver. temperature cooling water, deg. F.	107	99	88	74	53

This table shows that under the foregoing conditions, 43-deg. water is required to obtain a vacuum of 29 inches.

Now, if we double the amount of cooling water, the power required by the circulating pump will be increased from 4 to 6 times and the temperature and vacuum will be:

Vacuum obtainable, in.	25	26	27	28	29
Corresponding temp. from steam table, deg. F.	134	126	115	101	80
Hotwell temperature, deg. F.	127	119	108	94	73
Temp. cooling water discharge, deg. F.	112	104	93	79	58
Temp. cooling water inlet, deg. F.	102	94	83	69	48
Aver. temp. cooling water, deg. F.	107	99	88	74	53

From the foregoing it will be seen that a 29-in. vacuum can be obtained with 48 deg. cooling water.

Now assuming that the air leaks are stopped so that the difference between the hotwell temperature and the vacuum temperature is reduced from 7 to 3 deg., we have the following temperatures and vacuum readings:

Vacuum, in.	25	26	27	28	29
Corresponding temp. from steam table, deg. F.	134	126	115	101	80
Temp. hotwell, deg. F.	131	123	112	98	77
Temp. cooling water, outgoing	121	113	102	88	67
Temp. cooling water, incoming	101	93	82	68	47
Aver. temp. cooling water, deg. F.	111	103	92	78	57

It will be evident from the foregoing that with a tight system and only 3 deg. temperature difference between the hotwell and that of the vacuum, we obtain practically the same results with half the amount of cooling water (48 to 58 and 47 to 67 deg.).

Now, to calculate the amount of air leaking to the condenser, assume the vacuum is 28 in., which corresponds to a temperature of 101 deg., also that there is a temperature difference of 7 deg. between the hotwell and the vacuum temperatures; thus the hotwell temperature = 101 — 7 = 94 deg. A temperature of 94 deg. corresponds to a vapor pressure of 1.61 in., thus 0.39 in. is the air pressure (1.61 + 0.39 = 2 in. = 28 in.) (Dalton's Law). Thus the air pump has to pump air at 0.39 in. pressure and 94 deg. temperature.

Find the volume of one pound of air under that condition. The volume of one pound of dry air at 32 deg. F. and 30 in. barometer = 12.38 cu.ft. Thus, according to Charles' Law, the volume at 94 deg. is $12.38 \times \frac{460 + 94}{460 + 32} = 13.95$ cu.ft.

The volume at 0.39 in. pressure is $\frac{30}{0.39} \times 13.95 = 1{,}072$.

Assume size of the air pump to be 22x18 in. and 80 r.p.m. double acting, thus the displacement per minute

$$= \frac{\pi \times 22^2 \times 18 \times 160}{4 \times 1{,}728} = 634 \text{ cu.ft.}$$

Assuming 50 per cent efficiency the pump would displace 317 cu.ft. and could therefore remove $\frac{317}{1{,}072} = 0.295$ lb. per min. or $0.295 \times 13.95 = 4.12$ cu.ft. of free air per minute. (A leakage of 4.12 is about twice as much as what is considered good practice.)

In a system that is tight, with a 3-deg. temperature difference, 1.9 cu.ft. of free air per minute is the usual amount of leakage. LEWIS H. BRICKHOUSE.

Cape Charles, Va.

The 160,000-Kilowatt Turbine-Generator for Hell Gate*

THIS unit was designed to provide the maximum attainable capacity in the available space. The machine will for the present be required for a normal service of only 50,000 to 100,000 kw., but if one or more of the older turbines fails, the new unit must be able to take over the load up to 160,000 kw. continuously. In spite of the large overload it was therefore necessary for the turbine to have good efficiency on low loads; that is, it was designed to have a flat efficiency curve. These conditions, together with the limited floor space, made it necessary to sacrifice efficiency at the best point, which is guaranteed at only 84.5 per cent, as against 86 or 87 attained on other machines. This is the engine efficiency from steam ahead of the throttle valve to the turbine coupling. No generator loss is included.

The unit is designed for an initial steam pressure of about 275 lb. per sq.in. and a temperature of 610 deg. F.

The steam rate is guaranteed at 11.3 lb. per kw.-hr. at 90,000 kw., including the steam extracted for heating the feed water to 208 deg. F. The corresponding heat rate is about 11,800 B.t.u. per kw.-hr., measured at the steam throttle, with credit for the heat returned to the feed water.

Floor space restricted the design to a two-cylinder layout, the high-pressure section running at 1,800 r.p.m. and generating 75,000 kw., the other low-pressure section running at 1,200 r.p.m. and generating 85,000 kw. Both are pure reaction turbines, the high-pressure of the single-flow type with a balanced piston, and the low-pressure of the double-flow type. Provision is made for the extraction of steam at two points for heating feed water.

The total weight of the entire unit is about 1,200 tons—730 in the turbine and 440 in the generators. The exhaust area aggregates 343 sq.ft.

Four steam valves mounted in a special valve chest are fitted for regulating purposes. At 50,000 kw. two valves are open, and at 90,000 kw. all four are open. On overload, steam is bypassed to the later stages of the high-pressure rotor through pipes provided with additional regulating valves.

The turbine is fitted with the standard type of Brown-Boveri oil-pressure governor. The two steam stop valves are also operated by oil pressure. Even the bypass valves are oil-operated. Excessive speed or loss of vacuum will shut down the machine automatically through release of oil pressure.

The alternators are built for a continuous output of 188,200 kva. at 13,800 volts and 60 cycles. They are cooled by a closed system of air circulation, with an outside fan coupled to the end of the mainshaft. Each of these fans is designed to circulate about 160,000 cu.ft. per hour. The design of these fans was developed with the aid of a working model to 1/20 scale. The arrangement of ducts (patented) has been developed to avoid complex connections and to provide a simple easily supervised system. A photograph of the model appeared in *Power*, Jan. 4.

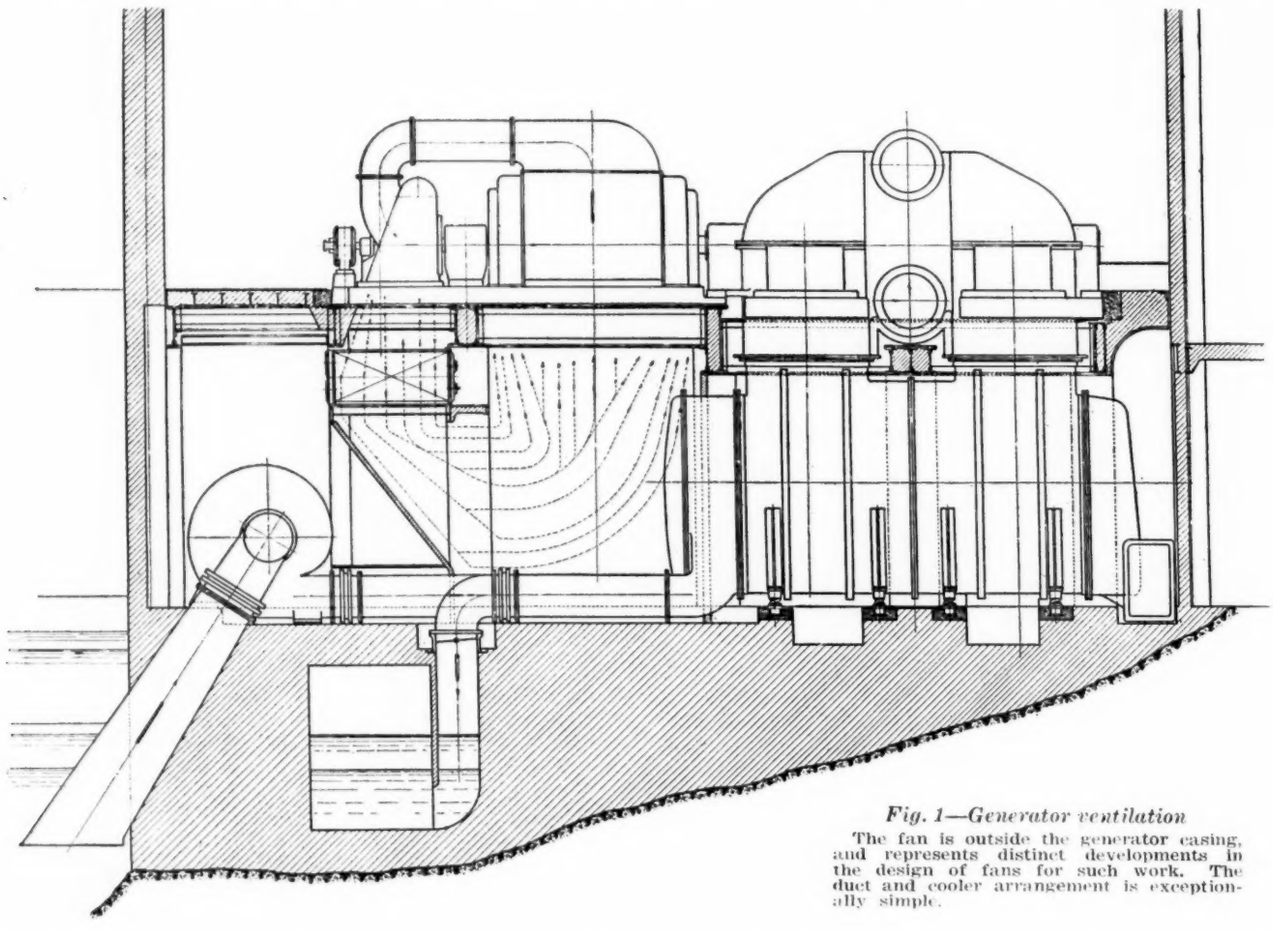


Fig. 1—Generator ventilation

The fan is outside the generator casing, and represents distinct developments in the design of fans for such work. The duct and cooler arrangement is exceptionally simple.

*Abstracted from an article in the *Brown Boveri Review* for January, 1927.

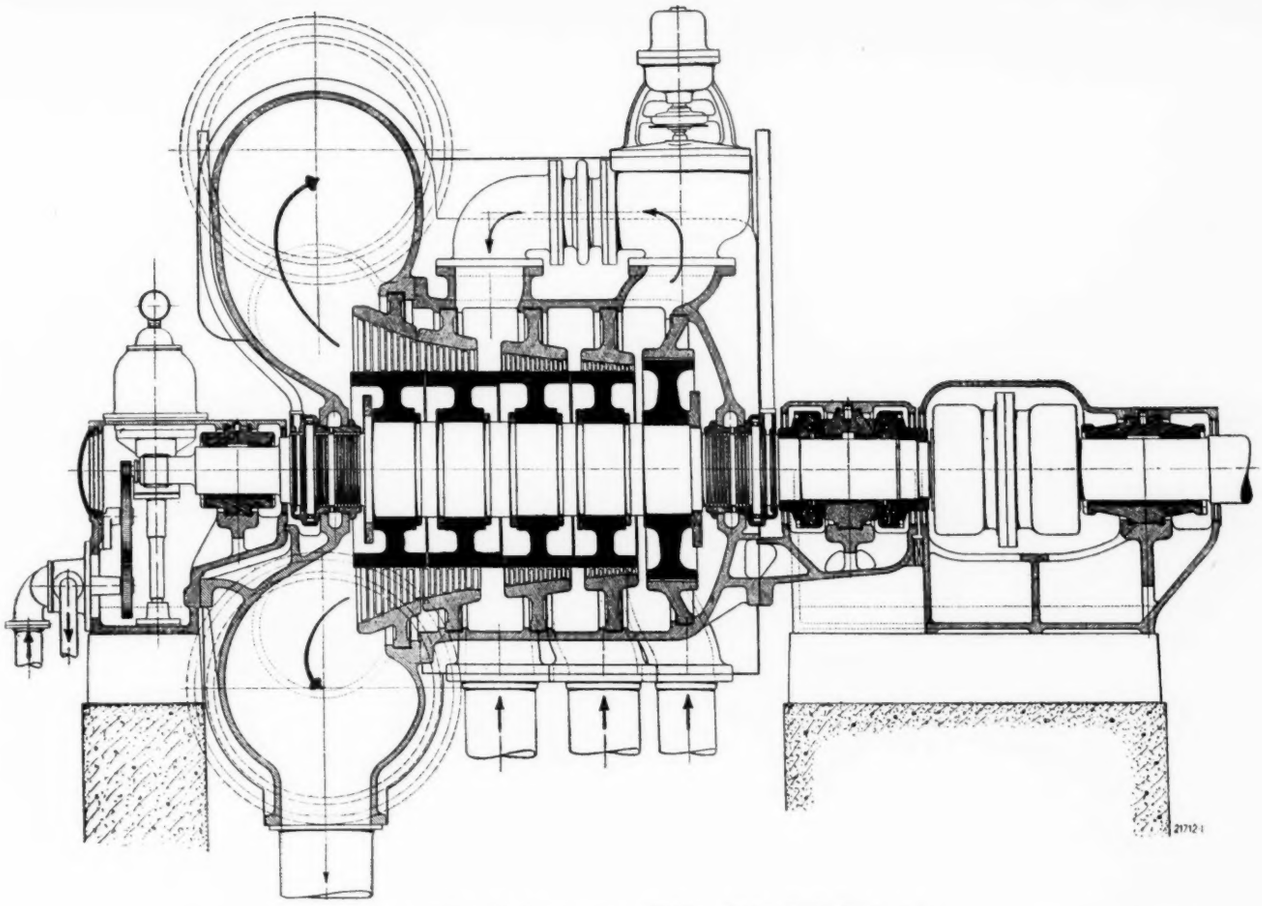


Fig. 2—The high-pressure section of the Hell Gate unit

The rotor is of the drum type, but the blading, both moving and stationary, is carried by steel cylinders, forged for the rotor and cast for the stator. This leads to simple designs for the casing and the shaft, with numerous advantages.

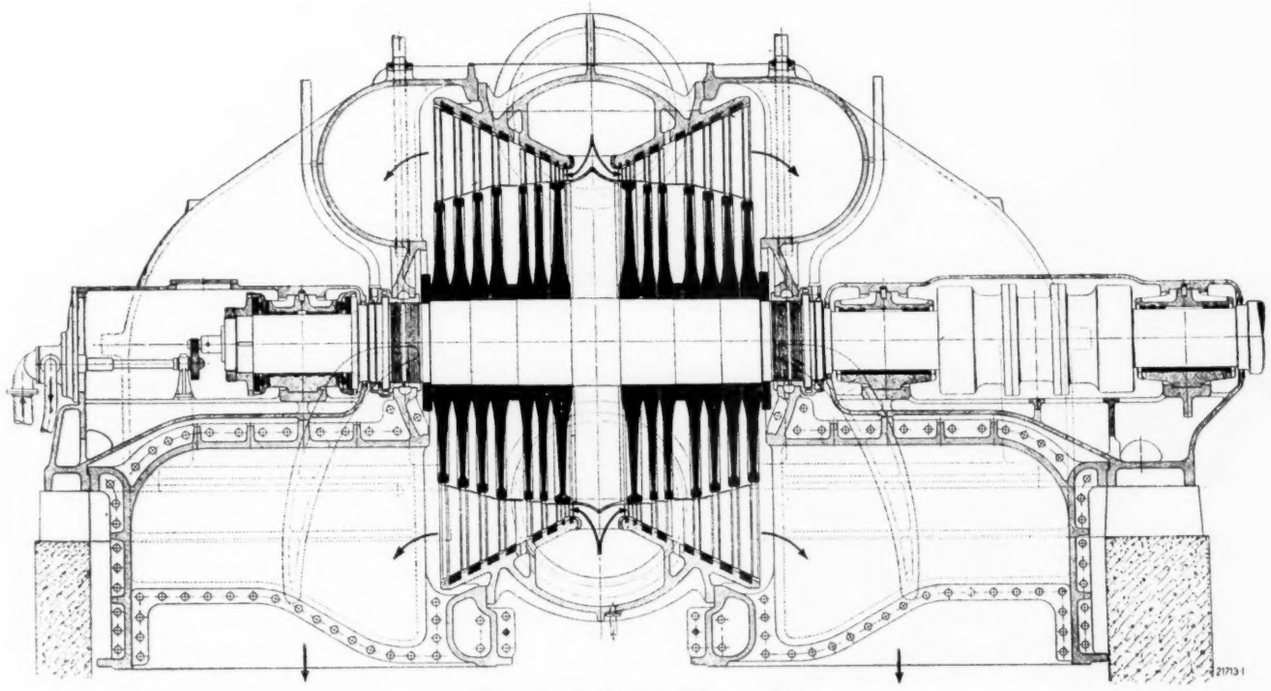


Fig. 3—The low-pressure section

The rotor is of the disk type, with double flow.

Power Generation in Brooklyn

Power Division Meeting of the A.S.M.E. Discusses Methods of Directing Operation of a Rapidly Growing Steam-Electric Generating System*

ON JANUARY 31 an audience of 500 or 600 members of the Metropolitan Section of the A.S.M.E. met for the discussion of the operating methods of the Brooklyn Edison Company, as set forth in five papers by the engineers of that organization.

Bert Houghton, operating superintendent, outlined the general policies of the company and described the organization through which they are carried out. The operating policy, he said, is to have sufficient equipment of all kinds in service at all times so that if the largest unit should be disabled, the remaining capacity will be adequate to carry the load. The basic problem is furnishing uninterrupted service for the least cost in material and labor.

H. A. Cox, engineer of steam operation, spoke on the system operation of steam and electrical equipment. He discussed the division of load among the three generating stations and the selection of fuel for them. The three stations are operated as a unit, to secure maximum economy for the system as a whole. Mr. Cox's remarks on maintenance will be abstracted more fully in a later issue.

H. M. Cook, engineer of tests, described methods of obtaining economical system operation. A division-of-load report containing all the necessary data for daily scheduling the proper division of load among the generating stations and among the machines in each station, is assembled each year for the ensuing year. Mr. Cook presented a valuable detailed description of the method followed in preparing this report.

From load forecasts and the curves showing proper station load distribution daily station load curves for each month are obtained.

Determining Performance

To determine the expected or ideal performance of the equipment in question, complete and accurate tests must be made following installation. To determine the actual performance at all times, check tests are made at intervals, and daily, weekly and monthly operating records are continually inspected, studied and compared.

To this end, daily reports are completed by noon of the next day, and are discussed by the operating staff at a meeting each afternoon. Mr. Cook showed several charts used to facilitate the speedy computation of results by clerks charged with this work.

Since operation of the stations is guided by the respective reports, if the reports are incorrect, due to erroneous or inaccurate fundamental data on which they are based, the operation will obviously not be up to standard. It follows, therefore, that the various station instruments, from which the necessary data for the reports are taken, must be known to be accurate at all times. To insure this exacting but necessary qualification, careful selection of the type of instrument installed is but one prerequisite. Very close and careful maintenance is of utmost importance.

W. C. Holmes, superintendent of the Hudson Avenue Station, described the equipment in his plant, and discussed the operating methods in use.[1]

NOWHERE in our organization are the basic qualities of reliability, obedience, honesty of purpose, punctuality, spirit of co-operation and quick judgment more essential than in the man who operates our stations. No man is suited to be an employee in a generating station or substation unless he is mechanically inclined and enjoys finding out how and why the equipment works in a certain way and how he can control any peculiarities of the machine or equipment. An employee in either a generating or substation must not make mistakes; a wrong valve closed or a wrong switch thrown might mean a serious shutdown. The operating force must thoroughly understand the unusual symptoms of system disturbances and be able to manipulate the equipment and the distribution of the load in emergencies. The operating personnel must possess cool judgment, the ability to decide quickly what to do in emergencies, and be self-possessed in the face of unusual occurrences and even personal danger.—*Bert Houghton.*

The efficiency of the turbine-room apparatus is practically fixed by the design, so that there is very little the operator can do to alter it.

The efficiency of the station is made or lost in the boiler room. But in order to get the boiler efficiency where it should be—and keep it there, which is much more difficult—it is first necessary to know just where the preventable losses are and the magnitude of each.

Mr. Holmes described the methods for determining losses. Coal weights and boiler outputs are determined with great care, and losses are calculated from temperature and flow observations. Results are published to the operating men, who thus know not only what the results have been, but also just what part each man played in securing those results. He described the system of automatic control and the auxiliary drive arrangements.

The best thermal performance of the station was 17,200 B.t.u. per kw.-hr. for May, 1926. The best boiler efficiency was 81 per cent, for June, 1926.

E. C. M. Stahl, assistant superintendent of the Hudson Avenue Station, spoke on the layout and operation of the electrical system of the company.

Discussion

George A. Orrok, consulting engineer of the New York Edison Company, called attention to the data indicating that after some 60,000 hours of operation, the steam rate of turbines is within the limits of error of the testing methods. He remarked that he has never been able to find any serious falling off in efficiency of turbines kept in good repair.

C. G. Spencer, of McClellan & Junkersfeld, called attention to the fact that the addition of an 80,000-kw. unit to the system is an evidence of the demand of the designer and financier for larger units, with the attendant lower first cost and superior economy. This unit comprises 27 per cent of the system capacity, which seems excessive, but Mr. Spencer cited a pioneer plant with ten 640-kw. units that added a 2,500-kw. unit in the year 1902. This was 28 per cent of the aggregate capacity. Evidently, the Hudson Avenue addition is not so radical as some maintain.

R. J. S. Pigott, consulting mechanical engineer, Public Service Production Company, commended the ingenious and intelligent application of the method of setting up load distribution schedules and outlined briefly the history of the development of the method, which is now widely used.

C. H. Smoot, president, Smoot Engineering Corporation, called attention to the emphasis on the human side of system operation.

John H. Lawrence, engineering manager, Thos. E. Murray, Inc., called attention to the neglect of the industrial plant, to which all the advances in the central station are available. The difficulty is to arouse the industrial owner to an appreciation of the savings that can be effected and the plant engineer to an intelligent command of the facilities available. He further called attention to the rapid growth of the ultimate capacity of uncompleted stations, due to advances in the power that can be put upon a unit area of ground, in both turbines and boilers.

In closing the discussion, Mr. Houghton showed a slide indicating that the present heat rate of the system (19,000 B.t.u. per kw.-hr.) is only 60 per cent of that prevailing in 1920.

*The five papers are to appear in *Mechanical Engineering*, and a limited number of preprints are available now.

[1]For descriptions of various portions of the equipment of Hudson Avenue, see *Power*, May 13, 1924, pp. 750 and 783; June 3, 1924, p. 915; June 24, 1924, p. 1016; Nov. 30, 1926, pp. 803 and 815; and Jan. 11, 1927, p. 52.

News in the Field of Power

Brooklyn Edison Opens New Hudson Avenue Unit

The formal opening and dedication of the new addition to the station of the Brooklyn Edison Co. at Hudson Avenue and East River, Brooklyn, N. Y., took place Feb. 2. A buffet luncheon was served to about 800 guests assembled in the turbine room.

The plant, which occupies a five-acre plot adjoining the Navy Yard, is equipped with an 80,000-kw. turbine-generator, reported the largest electric generator now in operation.

Matthew S. Sloan, president of the Brooklyn Edison Co., William A. Prendergast, chairman of the Public Service Commission, and others made addresses on the occasion. Mr. Prendergast threw on the switch of the unit. After the luncheon the guests were taken on a well-directed tour of inspection.

In reviewing coal consumption in power-plant operation and the steady trend toward greater economy through more efficient practice, Mr. Sloan stated that "this station uses an average of barely more than one pound of coal per kilowatt-hour. The present unit we are putting into operation today," he pointed out, "uses less than one pound of coal per kilowatt-hour of energy generated.

"Our company has already more than $30,000,000 in the building and the equipping of this station. When it is completed, it will have four more great generators, representing an expenditure of between $50,000,000 and $60,000,000. We are not spending these huge sums of money for the pleasure of spending, or so that we can say we have the largest generator in the world, or that we are building a million horsepower plant. We are putting this investment into plant and equipment which is used and will be used in forwarding the growth of our community and in the building up of prosperity."

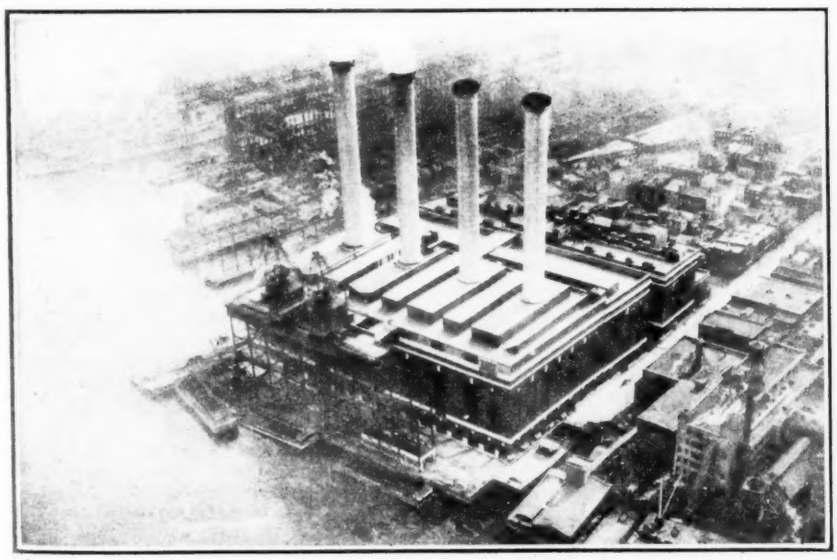
Indiana N.A.S.E. Convention Slated for May 27-28

Preparations are being made for the annual state meeting of the Indiana branch of the National Association of Stationary Engineers, which is to convene this year at Anderson, May 27 and 28.

At a special session held Jan. 28, Anderson members of the N.A.S.E. named committees and formulated further plans, arranging that all sessions will be held in the local Y.M.C.A., where a number of special features of entertainment will be offered. According to Frederick L. Ray, local chairman, a much larger attendance is expected than that which gathered for the state meeting held at Anderson four years ago.

Some of the speakers will be: John Quincy Adams, Duluth, Minn., national president; Fred W. Raven, Chicago, national secretary, and F. D. Sleet, Detroit, chairman of the national education committee. An exposition of power-plant equipment, at which many exhibitors will participate in the display, will form an adjunct to the convention.

A. J. Renthro, president of the Anderson N.A.S.E., named the committee on general arrangements, which chose George S. Billman, secretary, and R. H. Zellar, treasurer.



Hudson Avenue Generating Station of the Brooklyn Edison Co.,

Plans for Electrotechnical Meeting Include Tour

Plans for the sixth plenary meeting and convention of the International Electrotechnical Commission, which will be held this year in Italy, have set the date of the opening meeting at Bellagio as that of Monday, Sept. 5.

In arranging the program proposed by the Italian Electrotechnical Committee, it was found necessary to advance slightly the date of opening meeting. The plenary meeting, proper, will be held at Rome at the end of the convention, Sept. 21.

On Sept. 4 the delegates will arrive at Bellagio, which is situated on Lake Como. The following week will be given over to meetings of the advisory committee, a commemoration Volta at Como on the occasion of the meeting of the Scientific International Congress Sept. 8, and an excursion to hydroelectric plants Sept. 11. On Sept. 13 the visitors will leave by special trains for Milan, where they will be the guests of the Milan Section of the Associazione Elettrotechnica Italiana. That evening they will arrive at Venice.

The plants at Santa Croce will be visited, and Sept. 16 a special train will leave for Florence. There two days will be passed, and two in Rome. The plenary session, Sept. 21, will conclude the program.

The Italian government has courteously agreed to place a special train at the disposal of the delegates for this tour.

Boulder Dam Development Is Urged by Hoover

Herbert Hoover, Secretary of Commerce, urged a spirit of compromise in consideration of the Boulder Dam project.

No legislative proposal, said Mr. Hoover, which would provide for flood control, irrigation and water power development on the Lower Colorado River, "is perfect at the start. I can not but feel that the major issues are overlooked in the consideration of secondary questions by the sister States of the Colorado Basin."

The bill, which recently was reported favorably by the House Committee on Irrigation and Reclamation, now is before the House Committee on Rules, pending action on a proposal to give it preference on the House calendar.

Delay in the decision of the Rules Committee has been caused, Chairman Snell, Republican, of Potsdam, N. Y., stated orally, by the desire of committee members to study carefully the reports and testimony and because the committee had been informed that representatives of California and Arizona were meeting in California in an effort to iron out some of the disputed points.

Byllesby System To Spend $61,500,000

Construction expenditures budgeted for the operated and affiliated public utilities of Standard Gas & Electric Co. for the year 1927 will total $61,500,000, according to an announcement by H. W. Fuller, vice-president in charge of engineering and construction, Byllesby Engineering and Management Corporation.

The largest expenditures under the 1927 budget will be made for the Pittsburgh properties, where a total estimated amount of $26,000,000 will be expended. The Colfax steam-electric generating station near Pittsburgh will be increased from 190,000 kw. to 270,000 kw. capacity. Extensive switching facilities will be installed in connection the the Brunot Island plant at Pittsburgh.

Next in volume and importance to the Pittsburgh situation is the continuation of work on the 108,000-hp. hydroelectric station for the Louisville Hydro-Electric Co., a subsidiary of the Louisville Gas & Electric Co., at the falls of the Ohio River at Louisville.

A hydro-electric development for the California-Oregon Power Co., on the north fork of the Rogue River, will be remarkable both for the rapidity with which it will be completed and for the unusually large amount of energy which will be made available.

Work on this plant, which will have an initial capacity of 15,000 kw., was started in January, 1927, and it is expected that it will in operation by Oct. 1 of this year. The initial development of 15,000 kw. will produce an annual output of 130,000,000 kw.-hr., while second and third units of the same size, to be installed as necessity for increased power becomes evident, will produce 110,000,000 kw.-hr. and 60,000,000 kw.-hr., respectively, or a total of 300,000,000 kw.-hr. from a 45,000 kw. development.

"These," says Mr. Fuller, "are the high spots of the 1927 construction program; the remainder consists largely in the installation of additions to existing plants and the construction of a large amount of transmission and distributing equipment."

Col. James L. Walsh Elected McGraw-Hill Vice-President

Announcement of the election of Col. James L. Walsh to be a vice-president of the McGraw-Hill Publishing Company was made January 17 by James H. McGraw, president.

Colonel Walsh on the same day resigned as assistant vice-president of the Bankers Trust Co. of New York, with which he had been connected for the last five years. He spent the last year in Chicago as resident officer in charge of Middle West business.

Colonel Walsh, a graduate of West Point, during the World War served as assistant to the Chief of Ordnance of the Army. He still holds the post of Chief of the New York Ordnance District and is a member of the Civilian Advisory Board, appointed to effect a reasonable degree of industrial preparedness in the metropolitan area.

In announcing appointment of the new vice-president, Mr. McGraw stated that his wide acquaintance with the bankers and industrial leaders of the country will be of immediate assistance to the sales staff of the McGraw-Hill Publishing Company.

Elihu Thomson Gets Faraday Medal of 1927

Swelling the number of notable honors and awards in recognition of his many achievements in the electrical field, word has been sent to Prof. Elihu Thomson, director of the Thomson

Prof. Elihu Thomson

Research Laboratory of the General Electric Co., Lynn, Mass., that he is the recipient of the Faraday medal for 1927 of the Council of the Institution of Electrical Engineers of England.

The award is made for "notable scientific or industrial achievements in electrical engineering, or for conspicuous services rendered to the advancement of electrical science." This new distinction follows in less than two years Dr. Thomas's award of the Franklin medal and a certificate of honorary membership in the Franklin Institute, bestowed May 20, 1925.

Prof. Elihu Thomson was awarded the Franklin medal and a certificate of honorary membership in the Franklin Institute on May 20.

Professor Thomson has taken out more than 600 patents, and his inventions in dynamo-electric machinery, electric welding, watt-hour meters, lightning arresters and magnetic arc extinguishers are deemed fundamental. For many years connected with the managing corporation of the Massachusetts Institute of Technology, he was one of the founders of the American Electric Co. which later was merged with the General Electric Company.

In 1889 he was president of the A.I.E.E. and was the first recipient of the organization's Edison medal. He has been awarded the John Fritz medal of four national engineering societies, the Kelvin medal, which was presented to him at the World Power Conference on July 11, 1924, the Hughes medal of the Royal Society of London, the Rumford medal, the Elliott Cresson gold medal by the Franklin Institute and twice the John Scott legacy medal and decorated by the French government.

Ohio River Edison To Have Additional Unit in 1928

The Ohio River Edison Co. are now having plans prepared for the installation of an additional 33,000-kw. unit with boilers and other auxiliaries at its Toronto Superpower Station.

This last addition will be placed in service in the fall of 1928. With this new equipment operating, the station will have a capacity of 132,000 kw. This increase in generating capacity has made necessary the doubling of the capacity of the transmission line so that the Ohio River Transmission Co. has been called upon to spend something over a million dollars in a double-circuit 132,000-volt steel tower transmission line from Toronto toward Youngstown. This should be in service early next year.

The large increase in demand of electric power has been due to the industrial activity and the electrification of several large industrial plants in the territory served by the Penn-Ohio System.

West Virginia Power Plans Cheat River Project

The West Virginia Power & Transmission Co. of Morgantown, W. Va., has filed formal application for a license covering its project on the Cheat River and tributaries in West Virginia and Pennsylvania.

The company's investigations show that its proposed Blackwater dam will create a reservoir of 130,000 acre-feet capacity. It is to be connected with two power houses where 48,000 hp. and 60,000 hp. respectively, will be installed. The Beaver Hole dam will create a 20,000 acre-feet reservoir. The power house to be operated in connection with that dam is to have an installation of 80,000 hp. The Rockville dam will create 12,000 acre-feet of storage and the Clifton dam 76,000 acre-feet. The power house to be fed from those reservoirs will be equipped with 50,000 horsepower.

In addition, there are to be two dams in the Middle Cheat, while future developments are proposed at Rowlesburg, St. George, Dry Fork, Shaver's Creek and Glady Fork.

Refrigerating Congress Will Meet in Rome

The fifth International Refrigerating Congress will be held in Rome, Italy, from Sept. 19 to Oct. 1, according to advices to the Department of Commerce from its office in that city.

The central committee, located at Via Gesu 6, Milan, has published the program of the congress, which contains also rulings covering the First National Exposition of the Refrigerating Industry which will be opened together with the congress. The exposition will cover both automatic refrigerating machinery and accessories for cold storage plants built in any part of the world.

New Hydro-Electric Plant for Black River

Work preliminary to the actual construction of the $5,000,000 hydro-electric power dam to be erected on the Black River near Piedmont, Mo., has been started by the Weldon Drilling Company.

The company that will erect the dam is the Black River Hydro-Electric Co. The officers are: H. D. Mepham, of New York, president; Col. E. E. Green of the American Bridge Co., St. Louis, treasurer; W. A. Fuller, of St. Louis, secretary and chief engineer; W. H. Meredith, of Poplar Bluff, Mo., vice-president and chief counsel.

The dam company has also arranged for the financing of the power-transmission lines and other work incident to the actual construction of the dam. It has sold approximately 80 per cent of the 15,000 hp. energy that will be produced by the dam.

The dam will be 130 ft. high, giving a head of 130 ft. The 59-year average flow of the river at this point has been 1,200 cu.ft. per sec.

Seattle Seeks To Develop Skagit River Power

The City of Seattle, Washington, recently filed an application for a license with the Federal Power Commission covering its Skagit River development. The application for a license follows on the heels of the action of the committee in authorizing the preliminary permit covering this project. The application for preliminary permit, however, was filed Nov. 3, 1924.

According to the data submitted with the application the Ruby dam will produce a reservoir of 3,500,000 acre-ft. capacity. The head would be 445 ft. and the primary capacity 83,000 hp. It is planned, however, to install at that dam six 54,000-hp. units. The Diablo dam will back up the river to the Ruby dam. Its capacity is calculated 90,000 acre-feet. The head which would be developed at that point is 320 ft. The primary capacity is estimated at 108,000 hp. Six 47,000-hp. units will be installed at that dam. The Gorge dam will create a reservoir holding 6,000 acre-feet. This water is to be used in the existing Gorge power plant. The primary capacity there is 150,000 hp. At present 75,000 hp. is installed. The ultimate installation, however, plans to make use of eight 37,500-hp. units.

Boiler Explosions Totals for Jan.-March, 1926

According to statistics compiled by the Hartford Steam Boiler Inspection and Insurance Co., published in *The Locomotive*, there occurred throughout the United States during the first quarter of 1926, 251 boiler accidents, or failures, including fractures and ruptures of fired pressure vessels.

Of this number 23 boilers exploded; 6 bulged and ruptured; 117 occurrences when sections of heating boilers cracked; 2 locomotive boilers exploded, 14 tubes failed; 8 blow-off pipe failures, and 10 accidents to fired hot water heaters.

The total number of fatalities from boiler accidents during this period reached 16, and 37 were injured.

Practically every state had one or more such accidents. There appeared little or no grouping, geographically.

Boiler Code Committee Will Discuss Dished Heads

The Boiler Code Committee of the A.S.M.E. will meet at 29 West 39th St., New York City, for discussion and presentation of papers on dished heads, with a careful review of the rules given in the various sections of the A.S.M.E. Boiler Construction Code for the calculation of dished heads, the evening of March 17.

Ripley Urges Federal Power Over Corporate Acts

Federal regulation of interstate corporate activities, in order properly to protect the investing public from dangers growing out of the complicated structure of the modern corporation, was suggested in a paper written by William Z. Ripley, professor of political economy at Harvard University, and read by A. A. Berle, Jr., at the fiftieth annual meeting of the New York State Bar Association.

Professor Ripley also laid stress on the necessity for fuller publicity in corporate accounts.

The impersonal nature of the modern corporation, he pointed out, and its management and control by a few "inside interests" tend constantly to undermine the rights of stockholders, and to arrogate to these "insiders" all future profit. The large utility companies, in his opinion, were the worst offenders in this respect.

Declaring that the first step necessary is protection of the stockholders' franchise, which he described as "retention by the participants in a great endeavor of their fair share of the future increment of profit," Professor Ripley asserted that adequate publicity of corporate accounts is an imperative need in dealing with the existing situation.

Illinois Univ. Plans Research Graduate Assistantships

To assist in the conduct of engineering research and to extend and strengthen the field of its graduate work in engineering, the University of Illinois maintains fourteen research graduate assistantships in its engineering experiment station. Two other such assistantships have been established under the patronage of the Illinois Gas Association.

These assistantships, for each of which there is an annual stipend of $600 and freedom from all fees except the matriculation and diploma fees, are open to graduates of approved American and foreign universities and technical schools who are prepared to undertake graduate study in engineering, physics, or applied chemistry.

Nominations to these positions, accompanied by assignments to special departments of the Engineering Experiment Station, are made from applications received by the director of the station each year not later than April 1. Dr. M. S. Ketchum is dean and director. The nominations are made by the executive staff of the station, subject to the approval of the president of the University.

Columbia Engineers To Aid Student Training

Dr. Nicholas Murray Butler, president of Columbia University, has appointed a committee of the alumni of the university's Engineering Schools "to study from the point of view of the practicing engineer some of the present problems relative to engineering training and research, and the duty and opportunity of Columbia University in regard to them." He explained that modern social and industrial organization demands readjustments in engineering training.

Milton L. Cornell of the class of 1905 has been named chairman of the committee.

N.E.L.A. Engineers Guests at New York Edison Plant

Members of the engineering committees of the N.E.L.A. were entertained at luncheon at the new East River generating station of the New York Edison Co. Feb. 3.

After brief addresses by J. W. Lieb, general manager of the company, and Philip Torchio, vice-president in charge of electrical engineering, the visitors were grouped in small parties and conducted through the plant. Following this inspection, a number were driven to the Kip's Bay station of the New York Steam Co., for a brief inspection.

McGraw-Hill Co. Changes St. Louis Address

Announcement has been made that the St. Louis office of the McGraw-Hill Publishing Co., formerly located in the Star Building, is now situated in new quarters in the Bell Telephone Building, St. Louis, Mo.

Personal Mention

Irving E. Moultrop, chief engineer of the Edison Co., completed thirty-five years of service Jan. 1. The occasion was celebrated by brief presentation exercises and remarks on Mr. Moultrop's distinguished record of achievement.

George S. Terry has joined the electrical division of Stone & Webster, Inc. Mr. Terry, a graduate of the University of London, England, did considerable power-station work in that country before coming to this country with the British War Mission in charge of Buffalo and the western New York District for the inspection of steel and munitions.

W. S. Hays, electrical engineer for several years engaged in power installation work for the General Electric Co. and at one time associated with the McGraw Publishing Co., which connection he terminated when the McGraw

and Hill interests merged, has been selected for the position of executive secretary of the Power Transmission Association.

Paul H. Brangs, formerly vice-president of the Heine Boiler Co., has left for a cruise to Havana, the West Coast of South America, across the Andes Mountains to the East Coast of South America, to Buenos Aires, Montevideo, Rio de Janeiro, Sao Paulo, Caracas, Venezuela, Trinidad, Barbadoes and Porto Rico. He will return to New York about the middle of April.

Lawrence W. Wallace, of Washington, D. C., executive secretary of the American Engineering Council, has been re-elected president of the Eye Sight Conservation Council of America for 1927. Mr. Wallace was also chosen a member of the board of directors for a three-year term. The Eye Sight Conservation Council is co-operating with the American Engineering Council in the safety and production study now approaching completion.

Society Affairs

A. S. M. E. metropolitan section will meet at 29 West 39th St., New York City the evening of Feb. 9 for a fuel division session. Coal preparation practices in the eastern coal fields and economics of domestic heating will be the topics under consideration.

The Providence Engineering Society, and affiliated and co-operating local sections of the national societies, will hold its eleventh annual banquet at the Hotel Biltmore, Providence, R. I., Feb. 16. Speakers will include Dr. Charles P. Berkey, chief geologist of the third Asiatic expedition, and Senator Edward Ford of Michigan.

Business Notes

The Powers Regulator Co. announces removal to 137 East 46th St., New York City.

The Graybar Electric Co. has opened a distributing house at 921 Barr St., Fort Wayne, Ind., with Fred M. Barley as sales manager and Harold T. Thompson, service manager.

The General Electric Co. has appointed C. O. Jones sales manager of the power transformer section of the company, assistant to the manager of the transformer division.

The Steere Engineering Co., Detroit, Mich., announces that all correspondence with that company should be addressed to the offices of the Semet-Solvay Engineering Corp., at 40 Rector St., New York City.

The Trico Fuse Manufacturing Co., Milwaukee, Wis., manufacturer of Trico renewable fuses, now carries a complete stock of all Trico products with its Seattle, Wash., representatives, the Albert S. Knight Co., 2203 First Ave., South.

The De Laval Steam Turbine Co., of Trenton, N. J., has opened an office in Portland, Ore., in the Northwestern Bank Building. K. B. Hall has been appointed manager.

Coming Conventions

American Boiler Manufacturers Association will hold meeting at Hotel Cleveland, Cleveland, Ohio, Feb. 11; A. C. Baker, secretary and treasurer, 801 Rockefeller Bldg., Cleveland, Ohio.

American Institute of Electrical Engineers. Winter convention at New York City, Feb. 7-10; F. L. Hutchinson, secretary, 33 West 39th St., New York City. Summer convention at Detroit, Mich., June 20-24 inclusive; Pacific Coast convention at Del Monte, Calif., Sept. 13-16.

American Society of Mechanical Engineers. Spring meeting at White Sulphur Springs, W. Va., May 23-26. Calvin W. Rice, secretary. Midwest regional meeting will be held in Kansas City, April 4-6 inclusive; F. S. Dewey, chairman of the Kansas City Section.

American Welding Society. Annual meeting at 29 West 39th St., New York City, April 27-28-29.

Chicago Power Show, at Chicago, Feb. 15-19. G. E. Pfisterer, managing director, 53 West Jackson Blvd., Chicago.

Engineering Institute of Canada. Richard John Durley, secretary, 176 Mansfield St., Montreal, Que. The forty-first annual general and general professional meeting which was held at Montreal on Thursday, Jan. 27, was adjourned to reconvene at Quebec City at the Chateau Frontenac Hotel Feb. 15, continuing on the two succeeding days.

Heating and Ventilating Exposition. Will be held at Twelfth Regiment Armory, New York City, March 14-19 inclusive.

Midwest Power Conference, at Chicago, Feb. 15-18. Sessions will be held in the Coliseum concurrently with the Chicago Power Show; G. E. Pfisterer, secretary.

National Association of Stationary Engineers—Annual convention, in conjunction with the Pacific Coast Power Show, will be held at the Ambassador Hotel, Los Angeles, Calif., Aug. 22-27 inclusive, John Topman, secretary, convention committee. New England States convention at Portland, Me., June 17-18. Thomas H. Clark, president, Worcester, Mass.; Robert Johnson, secretary, 65 Charlotte St., Worcester, Mass. Indiana State convention at Anderson, May 27-28; George S. Billman, secretary.

National Board of Boiler and Pressure Vessel Inspectors. Annual meeting at Nashville, Tenn., during second week of June.

National Electric Light Association. A. Jackson Marshall, secretary, 29 West 39th St., New York City. Annual convention at Atlantic City, week beginning June 6.

National Marine Engineers' Beneficial Association. Fifty-second annual convention at the Hotel Franklin Square, Washington, D. C., Feb. 14-19. Albert L. Jones, secretary-treasurer.

The Allen-Bradley Co., 286 Greenfield Ave., Milwaukee, Wis., has recently added the Type J-1552 Form B switch to its standard line of across-the-line starting switches. The Form B size marks a new development in magnetic motor starting switches, because it extends the advantages of push-button control, thermal overload relays, and no-voltage protection to the smaller sizes of motors.

The International Combustion Engineering Corp. announces its removal with its American subsidiaries, Combustion Engineering Corp., Ladd Water Tube Boiler Co., and Raymond Bros. Impact Pulverizer Co., to the International Combustion Building, Madison Avenue at 35th and 36th Sts., New York City.

Fuel Prices

COAL

The following table shows the trend of the spot steam market in various coals, f.o.b. mines; mine run except Pittsburgh gas slack:

Bituminous Net Tons	Market Quoting	Jan. 31 1927
Pool 1	New York	$3.00@$3.25
Smokeless	Boston	2.28
Clearfield	Boston	2.25@ 2.50
Somerset	Boston	2.40@ 2.65
Kanawha	Columbus	1.50@ 1.75
Hocking	Columbus	2.25@ 2.75
Pittsburgh	Pittsburgh	1.90@ 2.00
Pittsburgh gas slack	Pittsburgh	1.50@ 1.60
Franklin, Ill.	Chicago	2.50@ 2.75
Central, Ill.	Chicago	2.00@ 2.25
Ind. 4th Vein	Chicago	2.25@ 2.50
West Ky.	Louisville	1.25@ 1.60
S. E. Ky.	Louisville	1.60@ 2.00
Big Seam	Birmingham	1.75@ 2.00
Anthracite Gross Tons		
Buckwheat No. 1	New York	2.50@ 4.50
Buckwheat No. 1	Philadelphia	2.50@ 4.50
Birdseye	New York	7.00

FUEL OIL

New York—Feb. 3, light oil, tank-car lots; 28@34 deg. Baumé, 5¾c. per gal.; 36@40 deg., 6¼c. per gal. f.o.b. Bayonne, N. J.

St. Louis—Jan. 19, tank-car lots, f.o.b. St. Louis; 24@26 deg., $2.05 per bbl.; 26@28 deg., $2.10 per bbl.; 28@30 deg., $2.15 per bbl.; 30@32 deg., $2.20 per bbl.; 32@36 deg., gas oil, 6.2c. per gal; 38@40 deg., 7c. per gal.

Pittsburgh—Jan. 27, f.o.b. local refinery; 30@34 deg., fuel oil, 6¼c. per gal.; 36@40 deg., fuel oil, 6⅝c. per gal.

Philadelphia—Jan. 26, 27@30 deg., $2.52@$2.58 per bbl.; 13@19 deg., $1.725@$1.785 per bbl.

Cincinnati—Feb. 1, tank-car lots, f.o.b. local refinery, 24@26 deg. Baumé, 6½c. per gal.; 26@30 deg., 6⅝c. per gal.; 30@32 deg., 7c. per gal.

Chicago—Jan. 25, tank-car lots, f.o.b. Oklahoma, freight to Chicago, 92c. per bbl.; 24@26 deg., $1.27½ per bbl.; 26@30 deg., $1.35; 30@32 deg., $1.65.

Boston—Jan. 31, tank-car lots, f.o.b. 12@14 deg. Baumé, 4⅜c. per gal; 28@32 deg., 6c. per gal.

Dallas—Jan. 29, f.o.b. local refinery, 26@30 deg., $1.73 per bbl.

Trade Catalogs

Automatic Compensators—The Electric Controller and Manufacturing Co. Bulletin 1042-F describes EC&M automatic compensators for 110 to 550 volts a.c. squirrel-cage and synchronous motors.

Standardized Speed Reducers—The Boston Gear Works Sales Co., Norfolk Downs (Quincy), Mass., has covered in a new booklet, Cl-27, a line of standardized speed reducers for industrial speed reduction.

Ball Mill Operation—The Hardinge Co., York, Pa., "Operation Notes for Ball Mill Users," Bulletin No. 24, gives 30 pages of comment on modern grinding practice and the operation of Hardings conical ball and pebble mills.

Automatic Pulverizers — The Raymond Brothers Impact Pulverizer Co., Chicago, Ill. This catalog, No. 19 goes quite into detail concerning various pulverizing problems and illustrates the different pulverizers as best adapted to various kinds of materials. It also includes the description of a complete air separating plant.

Limit Stops—The Electric Controller and Manufacturing Co. Bulletin 1037-C describes Type B limit stops for use with alternating and direct current motors. These limit stops are used on electric cranes and any other motor driven machine which must be automatically stopped when reaching a given position.

Welding and Cutting Equipment—The Smith Welding Equipment Corp., 1526 Race St., Philadelphia, Pa., issues catalog No. 7 on the welding and cutting equipment manufactured by the company. The equipment listed, with many illustrations showing complete apparatus, sectional views and parts, covers the whole field of welding.

Westinghouse Achievements — "The Engineering Achievements of the Westinghouse Electric and Manufacturing Co. for the Year 1926" by H. W. Cape, assistant director of engineering, describe and illustrate the work done by the company in the fields of electric generation and distribution of power, steam turbines, condensers and stokers, marine transportation, traction, the industries and radio.

Softening Water for Steam Boilers—The Cochrane Corp., manufacturers of steam power plant equipment, Philadelphia, Pa., have issued Bulletin No. 670 devoted to such topics as the design of the apparatus used in the hot process and the uses of the hot process softener for purposes other than softening boiler feed water, as in paper mills, packing houses, etc.

Filters—Bulletin No. 673, published by the Cochrane Corp., Philadelphia, describes pressure filters including a novel and highly interesting form in which strainer heads or pipe manifolds are not employed to withdraw the water from the bottom of the filter or to effect the distribution of the wash water, both functions being performed by the shape of the filter casing. The latter consists of a cylindrical shell with the apex below, and water is withdrawn from an inverted cone embedded in the gravel layer inside, no small orifices being necessary. For convenient operation of this filter an ingenious single control valve has also been perfected. Filter, filtering to waste and backwashing positions are indicated on a dial with which the handle is normally locked in each of the positions. The act of pulling out the handle in order to move it simultaneously lifts the plug valve from its seat, so that the valve turns easily and without scoring or cutting. The pamphlet also describes several forms of chemical proportioners for dosing the water to be filtered with coagulant. The removal of oil from condensate by means of coagulation and filtration is also discussed.

New Plant Construction

Ark., Hawes—Dierks Lumber & Coal Co., 700 Gates Bldg., Kansas City, Mo., will build a power plant, etc. by day labor. Estimated cost $500,000. Private plans.

Ark., Prescott—Southern Ice & Utilities Co. of Texas, Santa Fe Bldg., Dallas, Tex., awarded contract for the construction of an ice plant here to E. W. Sproul Co., 2001 West Pershing Rd., Chicago, Ill. Estimated cost $150,000.

Calif., Los Angeles — Sears Roebuck & Co., Arthington and Homan Sts., Chicago, Ill., awarded contract for the construction of two 9 story mercantile buildings one East 9th St. and the other at Saluson, Vermont and Menlo Aves. Scofield Engineering Construction Co., Pacific Finance Bldg. Total estimated cost $5,000,000.

Calif., Los Angeles—Syndicate, c/o E. R. Rockwell Corp., Lincoln Bldg., plans the construction of a 5 story hotel, including steam heating system at Carthay Center. Estimated cost $500,000. S. Brown, New Orpheum Bldg., is architect.

Calif., Oakland—Pacific Ice Co., 354 Pine St., San Francisco, awarded contract for the construction of an ice plant at East 10th and High Sts. to H. E. Heller, 320 Market St. Estimated cost $40,000. Owner is in the market for equipment.

Ill., Albion—City will soon receive bids for the construction of two sewage pumping stations, electric driven automatic and Imhoff tank and sludge bed, etc. Estimated cost $94,616. Caldwell Engineering Co., 36 North Side Sq., Jacksonville, is engineer.

Ill., Chicago—W. C. Bannerman & Co., 77 West Washington St., is having plans prepared for the construction of a 16 story apartment at Wellington and Sheridan Rd. Estimated cost $3,500,000. Robert DeGoyler & Co., 307 North Michigan Ave., are architects.

Ill., Chicago—Bd. of Education, 650 South Clark St., awarded contract for the construction of a power plant at 5101 Linden Ave. Estimated cost $500,000.

Ill., Chicago — Koenigsberg & Weisfeld, 155 North Clark St., Archts., will soon receive bids for the construction of a 7 story apartment including elevators at 4536 Magnolia Ave., for S. Clifford & Co., 111 West Washington St. Estimated cost $1,000,000.

Ill., Chicago—Lockwood, Greene & Co., 400 North Michigan Ave., Engrs., are receiving bids for the reconstruction of boiler room, also the installation of two or three 400 hp. water tube boilers for American Hide & Leather Co., 1320 Elston Ave. Estimated cost $30,000.

Ill., Chicago—F. Stanton, 310 South Michigan Ave Archt., will receive bids about Feb. 1 for the construction of a 12 story apartment including steam heating system 2 elevators, etc. at 6317 Kenmore Ave. for W. B. Eldred, 6244 Winthrop Ave. Estimated cost $500,000.

Ill., Dupo—City will soon receive bids for the construction of a complete waterworks and distribution system including pump house, one motor driven and one gasoline engine driven centrifugal pumps, 100,000 gal. tank on tower, etc. Estimated cost $125,000. Schwab & Sheppard, 15 Faulstich Bldg., Alton, are engineers.

Ill., Troy—City is having preliminary plans prepared for the construction of a complete electric light and power plant. Estimated cost $65,000. Edward Flad & Co., 916 Chemical Bldg., St. Louis, Mo., are engineers.

Ind., Hammond—Harter Industrial Dist., C. Retz, Mgr., had plans prepared for the construction of a central heating and power plant at 151st. and Columbia Ave. Estimated cost $1,500,000. Private plans.

Ind., Terre Haute—Wadley Co., 1st and Poplar Sts., is receiving bids for the construction of a cold storage plant at 615 South 6th St. Estimated cost $150,000. G. Lehle, 3810 Broadway, is architect.

Ia., Eagle Grove—City plans an election Feb. 18 to vote $65,000 bonds for the construction of an electric light and power plant. H. L. Cory & Co., Aberdeen, S. D., are engineers.

La., Crowley—City plans an election Mar. 8 to vote $120,000 bonds for improvements to waterworks and power plant.

Mass., Saugus—Town, C. H. Light, Chn. of Committee, is having plans prepared for the construction of a pumping station, etc. on Vine St. Estimated cost $25,000. E. T. Hartman, 37 State House, Boston, is engineer.

Mo., Piedmont—Black River Hydro Electric Co., c/o Harrington, Howard & Ash, Ovar-Leslie Bldg., Kansas City, Mo., Engrs., is having plans prepared for the construction of a power plant and dam on the Black River here.

Mo., St. Louis—Mauran, Russell & Crowell, Chemical Bldg., Archts., will receive bids about Feb. 11 for the construction of a 22 story office building at 13th and Pine Sts. for Missouri Pacific R.R., Railway Exchange Bldg. Estimated cost $2,000,000. E. A. Hadley, is chief engineer.

Neb., Omaha—Hotel Hannan, 3002 Farnum St., awarded contract for the construction of a 10 story hotel at 30th and Farnum Sts., to C. L. Gray, 1309 McCausland St. and C. R. Crockwell, 611 Hanley St. Estimated cost $2,250,000. Refrigeration plant, water softening plant, ventilation system, etc., will be installed.

N. J., Bayonne—Bayonne Hospital, L. F. Donohue, Chn., will soon receive bids for the construction of a 7 story hospital, including steam heating system, elevators, etc., on East 30th St. Estimated cost $500,000. Crow, Lewis & Wick, 200 5th Ave., New York, N. Y., are architects.

N. J., Newark—Medical Towers, W. E. Lehman, Pres., 972 Broad St., Archt., will build an office building, including steam

heating system, elevators, etc., on Lincoln Pl. Estimated cost $500,000. Work will be done by separate contracts.

N. J., Totowa (mail Paterson) — State Institutions and Agencies, State Bldg., Trenton, will soon award contract for the construction of a group of buildings including power house, etc., for Training School for Feeble Minded Females here. C. N. Leathem, Jr., State Bldg., Trenton, is architect.

N. Y., Bronxville—Hutchinson Hale Inc., c/o Walker & Gillette, 128 East 37th St., New York, Archts., is having plans prepared for the construction of a hotel including steam heating system, elevators, etc., on Parkway Rd. here. Estimated cost $500,000.

N. Y., Brooklyn — Montague Terrace Corp., 189 Montague St., awarded contract for the construction of an 11 story apartment to Wm. Kennedy Construction Co., 215 Montague St. Estimated cost $550,000. Steam heating system will be installed.

N. Y., New York—Central Union Trust Co., 80 Broadway, is having plans prepared for the construction of a 43 story bank and office building including steam heating system, elevators, etc., at Broadway and Wall St. Estimated cost $12,000,000. Cross & Cross, 385 Madison Ave., are architects.

N. Y., New York—Hunter College, City Bd. of Education, 500 Park Ave., is having plans prepared for the construction of a college including steam heating system, elevators, etc. at Park Ave. and 68th St. Estimated cost $1,000,000. W. H. Gompert, Flatbush Ave. Ext., Brooklyn, is engineer.

N. Y., New York—Irons & Hoover, Inc., 101 Park Ave., will soon receive bids for the construction of a 15 story apartment, including steam heating system, elevators, etc., at 442 East 57th St. Estimated cost $700,000. Rouse & Goldstone, 512 5th Ave., are architects.

O., Akron—J. Schrembs, plans the construction of a 6 story hospital and nurses' home including power house at North Main and Olive Sts. Estimated cost $800,000. F. C. Warner and W. R. McCormack, Bulkley Bldg., Cleveland, are engineers.

O., Cincinnati — Cleveland, Cincinnati, Chicago & St. Louis, Ry. Co., 230 East 9th St., awarded contract for the construction of a power house on Hillside St. to Big Four R.R. Co., Ingalls Ave. Estimated cost $550,000.

O., Cleveland — Syndicate, c/o W. J. Wefel, 5716 Euclid Ave., Archt. and Engr., is having sketches made for the construction of a 12 story office and stores building including steam heating system, boilers, etc. Estimated cost $2,000,000.

Okla., Chickasha—City is having plans prepared for waterworks improvements including pumping equipment, mains, etc. Estimated cost $40,000. R. O. Bradley & Co., are engineers.

Okla., Fairfax — State Drainage Bd., Capitol, Oklahoma City, is having preliminary surveys made for the construction of a 30,000 hp. hydro-electric plant on the Arkansas River near here. Estimated cost approximately $3,000,000. T. C. Hughes, 205 Cole Bldg., Tulsa, is engineer.

Okla., Ponca City—City voted $300,000 bonds for extensions and improvements to electric light and power plant including two Diesel engines, etc. Burns & McDonnell Engineering Co., 400 Interstate Bldg., Kansas City, Mo., are engineers.

Pa., Philadelphia — Philadelphia College of Pharmacy & Science, W. C. Brainsted, Pres., 145 North 10th St., plans the construction of a college and boiler house at 43rd and Kingsessing Sts. N. Hulman, 1524 Chestnut St., is architect.

Pa., Pittsburgh—J. I. Simon, 527 5th Ave., awarded contract for the construction of a 12 story office building at 6th Ave. and Ross St., to Fred T. Ley Co., 578 Madison Ave., New York, N. Y. Estimated cost $900,000. Steam heating system, electric elevators, etc., will be installed.

Tex., El Paso—El Paso Electric Co., T. Walker, Mgr., is having plans prepared for improvements to electric underground system, sub-stations, etc., also the installation of two high pressure boilers. Private plans.

Tex., Ft. Worth—Lone Star Ice & Fuel Co., North 21st and Calhoun Sts., awarded contract for the construction of an ice plant at 21st and Loving Sts. to J. D. Little, 1313 Clinton St. Estimated cost $50,000.

Tex., Orange—Latex Gas Co., F. N. Lege, Pres., subsidiary of Magnolia Gas Co., is having plans prepared for the construction of a natural gas pipe line from Orange county to Dallas, a distance of 200 miles, also compressor stations along the route. Estimated cost approximately $10,000,000. Private plans.

W. Va., Cedar Grove — Town plans an election Feb. 24 to vote $30,000 bonds for waterworks improvements including reservoir, pumps, etc.

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C. Z., Darien—Bureau of Yards & Docks, Navy Dept., L. E. Gregory, Ch. of Bureau, Washington, D. C., plans the construction of a water purification plant including motor driven centrifugal pump, etc. at Naval Radio Station here.

Equipment Wanted

Ala., Midland—R. M. Brown, prices and catalogs on hot water heaters for homes.

D. C., Washington—A. L. Flint, General Purchasing Officer of the Panama Canal, will receive bids until Feb. 17 for equipment for tow boats including refrigerating machines, etc.

Ill., Chicago—Lockwood, Greene & Co., 400 North Michigan Ave., Engrs., are receiving bids for two or three 400 hp. water tube boilers for American Hide & Leather Co., 1320 Elston Ave.

Ill., Dupo—City will soon receive bids for one motor driven and one gasoline engine driven centrifugal pumps for proposed waterworks and distribution system.

Ill., Thebes—City will soon receive bids for one 500 g.p.m. gasoline engine driven and one 500 g.p.m. electric motor driven centrifugal pumps, one 1,900 g.p.m. electric driven wash pump, one 210 g.p.m. gasoline engine driven and one 210 g.p.m. electric motor driven centrifugal high lift pumps, 40,000 gal. tank or tower, etc. Estimated cost $65,000. Caldwell Engineering Co., 36 North Side Sq., Jacksonville, is engineer.

Ind., Frankfort—City plans to purchase new turbine for electric light plant. Estimated cost $85,000.

Ia., Jewell—City, C. V. Campbell, Clk., will receive bids until Feb. 11 (extended date) for deep well pump, single stroke 80 g.p.m. at 30 crank r.p.m. or double stroke 100 g.p.m. at 30 crank r.p.m., motor, 220 v. 1,200 r.p.m., 10 hp., 3 ph. a.c., and 10 hp. single ph. 15 hp., 3 ph. and 15 hp. single ph. motors, 75,000 gal. tank on tower, etc., for waterworks improvements. Henningson Engineering Co., 12th and Harney Sts., Omaha, Neb., is engineer.

Ky., Princeton—City, O. N. Cartwright, Clk, City Hall, will receive bids until Feb. 14 for two 350 g.p.m. low service motor driven horizontal centrifugal pumps, 194 ft. head, two 350 g.p.m. high service motor driven centrifugal pumps, 175 ft. head, and one 500 g.p.m. automobile type gasoline engine driven horizontal centrifugal pump for waterworks improvements.

Md., Hagerstown—Bd. of Street Comrs., City Hall, will receive bids until Feb. 15 for steam turbine generators, boilers and superheaters, surface condensers, stokers, oil circuit breakers, switchboard and switchboard equipment, etc. for electric light plant.

Tex., El Paso—El Paso Electric Co., T. Walker, Mgr., will be in the market for machinery and equipment for electric substations.

Pa., Pittsburgh—Dept. of Public Works, Bureau of Water, will receive bids until Feb. 17 for electric motor driven centrifugal pumps with controlling appurtances, wiring and piping for Howard pumping station, Howard St. N. S. Estimated cost $110,000.

Wis., Hartford—City, W. Radtke, Clk, will receive bids until Feb. 15 for furnishing and installing a bleeder type turbo generator, surface and jet condensers, uniflow engine generating set, cooling tower, etc. C. A. Cahill & Sons, 217 West Water St., Milwaukee, are engineers.

Alta, Calgary—Machinery Depot, is in the market for a vertical engine and 100 to 150 kw., 2,300 v., 3 ph., 60 cycle alternator.

Ont., Hamilton—City plans the installation of electrically operated pumps in connection with waterworks improvements. Estimated cost $40,000. W. McFaul is city engineer.

Que., Montreal—A. S. Foreman, 232 St. James St., is in the market for 1,000 and 2,000 ft. air compressors for motor drives, automatic veritcal steam engine, 60 in. x 14 ft. boiler, 15 to 18 hp. vertical boiler and 8 x 8 in. printing press.

N. Z., Wellington—Dept. of Public Works, will receive bids until April 26 for 56 acid cells complete, 24 hydromotors, 2 cell voltmeters, 6 spare cells complete, 12 spare connecting volts, 24 spare glass separators, etc.

PRICES - MATERIALS - SUPPLIES

Electrical prices on following page are prices to the power plant by jobbers in the larger buying centers east of the Mississippi. Elsewhere the prices will be modified by increased freight charges and by local conditions.

SINCE LAST MONTH

ONE or two minor price advances were all that occurred to offset the declining tendencies, which developed in the accompanying list of power-plant and electrical supplies during the month. The two increases referred to, were in linseed oil and wire solder. The market tends downward with demand slower, in cement, cotton waste, rivets, babbitt metal, armored cable, rubber-covered copper wire, friction and rubber tape.

POWER-PLANT SUPPLIES

HOSE—Quotations at New York warehouses:

	Fire Protection	50-Ft. Lengths
Underwriters' 2½-in., coupled, single jacket	(net)	68c. per ft.
Common, 2½-in., cotton-rubber lined	80c. per ft. list less	50%

Air—Best grade

¼-in., per ft.	3-ply	$0.34	4 ply	$0.42

Steam—Discounts from List

First grade	40%	Second grade	40–5%	Third grade	50%

RUBBER BELTING—List price 6-in., 6 ply, $1.83 per lin.ft. The following discounts from list apply to rubber transmission belting:

Best grade	50%	Second grade	50–10%

LEATHER BELTING—List price, 24c. per lin.ft. per inch of width for single ply at New York warehouses

Grade	Discount from list
Medium	40–5%
Heavy	30–10%

RAWHIDE LACING—For cut, best grade, 50%, 2nd grade, 60%. For laces in sides, best, 41c. per sq.ft.; 2nd, 37c. Semi-tanned: cut, 50%; sides, 41c. per sq.ft.

PACKING—Prices per pound at New York warehouses:

Rubber and duck for low-pressure steam, ⅛ in.	$1.05
Asbestos for high-pressure steam, ⅛ in.	1.85
Duck and rubber for piston packing	1.05
Flax, regular	1.15
Flax, waterproofed	1.70
Compressed asbestos sheet	.95
Wire insertion asbestos sheet	1.40
Rubber sheet	.60
Rubber sheet, wire insertion	.85
Rubber sheet, duck insertion	.65
Asbestos packing, twisted or braided and graphited, for valve stems and stuffing boxes	1.40
Asbestos wick, ½- and 1-lb. balls	.50

PIPE AND BOILER COVERING—Discounts, New York warehouses, are as follows:

85% magnesia high pressure		50%
Asbestos, air cell, for low-pressure heating and return lines	4-ply	70%
	3-ply	72%
	2-ply	74%

PORTLAND CEMENT—New York, $2.35@$2.50 per bbl. without bags, in carload lots delivered on job. Bag charge of 40c. per bbl.

STRUCTURAL STEEL—New York delivered price, 3 to 15-in. beams and channels and 3 to 6-in. angles, tees, and plates, all $3.34 per 100 lb.

COTTON WASTE—The following prices are in cents per pound:

	New York	Cleveland	Chicago
White	13.00@17.50	16.00	15.00@20.00
Colored	9.00@13.00	13.00	12.00@17.00

WIPING CLOTHS—Prices per pound in lots of about 600 lb., for washed, white wipers, as follows:

Chicago	$0.15
New York	.17½
Cleveland (*per thousand*)	36.00

LINSEED OIL—These prices are per gallon:

	New York	Cleveland	Chicago
Raw in barrels (5 bbl. lots)	$0.84¾	$0.98	$0.85

WHITE AND RED LEAD—Per 100-lb. keg, base price, f.o.b. New York:

	Dry		In Oil	
	Current	1 Yr. Ago	Current	1 Yr. Ago
Red	$15.25	$15.25	$16.75	$16.75
White	15.25	15.25	15.25	15.25

RIVETS—The following quotations are allowed for fair-sized orders from warehouse:

Rivets, ⅞x1-in. and longer, 19c. per lb., less 50% at New York warehouses. Same discount for tinned. EXTRA per 100 lb. for 1⅛ to 2-in. long, all diameters, 25c.; ¾-in. dia., 35c.; ⅝-in., dia., 75c.; 1-in. long and shorter, 75c.; longer than 5-in., 50c.; less than 200 lb., 50c.; countersunk heads, 45c.

Structural rivets, per 100 lb.:

New York	$4.20	Chicago	$3.50	Pittsburgh	$2.30@$2.60

Cone-head boiler rivets, per 100 lb.:

New York	$4.40	Chicago	$3.70	Pittsburgh	$2.90

REFRACTORIES—Prices in car lots f.o.b. plant:

Chrome brick, eastern shipping points	net ton	$45.00
Chrome cement, 40@50% Cr_2O_3, in bulk	net ton	22@25
Chrome cement, 40@50% Cr_2O_3, in sacks	net ton	26@29
Magnesite brick: 9-in. straights	net ton	65.00
Magnesite brick: 9-in. arches, wedges and keys	net ton	71.50
Magnesite brick: Soaps and spits	per ton	91.00
Silica brick: Mt. Union, Pa.	per M	43.00
Clay brick, 1st quality, 9 in. shapes, Pennsylvania	per M	40@45
Clay brick, 1st quality, 9 in. shapes, Ohio	per M	40@43
Clay brick, 1st quality, 9 in. shapes, Kentucky	per M	40@43
Clay brick, 1st quality, 9 in. shapes, Maryland	per M	43@46
Clay brick, 2nd quality, 9 in. shapes, Pennsylvania	per M	33@38
Clay brick, 2nd quality, 9 in. shapes, Ohio	per M	38@40
Clay brick, 2nd quality, 9 in. shapes, Kentucky	per M	38@40
Clay brick, 2nd quality 9 in. shapes, Maryland	per M	38@40
Chrome ore crude, 40@50%	net ton	18.00@22.50

BABBITT METAL—Delivered, New York, cents per lb.:

Genuine, highest grade	84.00
Commercial genuine, intermediate grade	61.00
Anti-friction metal, general service	31.50
No. 4 babbitt (f.o.b.)	13.25

COLD DRAWN STEEL—Warehouse prices are as follows:

	New York	Cleveland	Chicago
Round shafting and screw stock, per 100 lb. base	$4.00	$3.90	$3.60
Flats and squares, per 100 lb. base	4.50	4.40	4.10

BOILER SPECIALTIES—F. o. b. New York or Jersey City, discounts on list

	Current
Copper ferrules	70%
Boiler flanges	65-5%
Boiler stay bolts	60%
Boiler patch bolts	10%
Boiler fitting-up bolts	45%
Pressed steel boiler lugs	10%

WROUGHT PIPE—The following discounts are to jobbers for carload lots at Pittsburgh mill:

BUTT WELD

Inches	Steel Black	Galv.	Inches	Iron Black	Galv.
1 to 3	62	50½	1 to 1½	30	12

LAP WELD

2	55	43½	2	23	7
2½ to 6	59	47½	2½	26	11
7 and 8	56	43½	3 to 6	28	13
9 and 10	54	41½	7 to 12	26	11
11 and 12	53	40½			

BUTT WELD, EXTRA STRONG, PLAIN ENDS

1 to 1½	60	49½	1 to 1½	30	14
2 and 3	61	50½			

LAP WELD, EXTRA STRONG, PLAIN ENDS

2	53	42½	2	23	9
2½ to 4	57	46½	2½ to 4	29	15
4½ to 6	56	45½	4½ to 6	28	14
7 and 8	52	39½	7 and 8	21	7
9 and 10	45	32½	9 to 12	16	2
11 and 12	44	31½			

BOILER TUBES—Following are prices in New York warehouse of tubes manufactured according to specifications of the American Society of Mechanical Engineers:

Size	Lapweld Steel	C. C. Iron	Seamless Steel
1	.....	.....	$17 07
1¼	.....	.....	19 20
1½	.....	$38 00	17 92
1¾	.....	28 50	20 48
2	$17 33	25 00	20 24
2¼	19 84	28 25	23 00
2½	21 60	34 00	26 03
3	25 50	42 50	27 04
3¼	30.25	49 50	30 67
3½	31.50	52 75	33 33
4	38.03	67 00	40.11

Tubes 2½ in. diameter, or smaller, over 18 ft. long, 10 per cent extra.
These prices are net per 100 ft. based on stock lengths. If cut to special lengths, billing will be based on the entire stock lengths.
In addition to the above, standard cutting charges are as follows:
2 in. and smaller, 5c. per cut. 3 in., 9c. per cut
2¼ and 2½ in., 6c. per cut. 3½ to 4 in., 10c. per cut

ELECTRICAL SUPPLIES

ARMORED CABLE—Price per 1,000 ft.—5 per cent 10 days.

B. & S. Size	Two Cond. M Ft.	Three Cond. M Ft.	Two Cond. Lead M Ft.	Three Cond. Lead M Ft.
No. 14 solid	$31.00 (net)	$50.00 (net)	$180.00	$220.00
No. 12 solid	136.00	180.00	225.00	275.00
No. 10 solid	185.00	235.00	275.00	325.00
No. 8 stranded	305.00	375.00	420.00	500.00
No. 6 stranded	440.00	530.00	615.00	.....

From the above lists discounts are:		Lead Covered
Less than coil lots	50%	20%
Coils to 1,000 ft	60%	30%
1,000 to 5,000 ft	62%	35%
5,000 ft. and over	65%	38%

CONDUIT, Price per 1,000 ft.; **ELBOWS AND COUPLINGS**, Per 100 pieces, f.o.b. New York, with 10-day discount of 5 per cent.

Size In.	Conduit Black Per M	Conduit Galvanized Per M	Elbows Black Per C	Elbows Galvanized Per C	Couplings Black Per C	Couplings Galvanized Per C
¼	$56.50	$61.34	$7.76	$8.83	$4.52	$4.92
⅜	72.07	78.63	10.21	11.63	6.46	7.03
1	103.31	113.00	15.10	17.21	8.39	9.13
1¼	139.77	152.88	20.51	23.07	11.78	12.75
1½	167.12	182.79	27.34	30.76	14.56	15.75
2	224.85	245.94	50.13	56.40	19.41	21.01
2½	355.50	388.85	82.03	92.28	27.73	30.01
3	464.88	508.50	218.74	246.10	41.59	45.01
3½	585.30	637.74	483.04	543.46	55.46	60.02
4	714.17	776.30	558.23	628.06	69.32	75.02

CONDUIT BODIES AND FITTINGS—Black or galvanized.

	Less than $10 list	$10 list to $100	$100 list and over
Standard package	10%	20%	28%
Less than standard package	5%	10%	20%

CUT-OUTS—Following are net prices each in standard-package quantities:

CUT-OUTS, PLUG, SOLID NEUTRAL OR 2 FUSE

S. P. M. L.	$0.12	D. P. D. B.	$0.31
D. P. M. L.	.16	T. P. S. B.	.35
T. P. M. L.	.27	T. P. D. B.	.47
D. P. S. B.	.16		

CUT-OUTS, N. E. C. FUSE, SOLID NEUTRAL OR 2 FUSE

	0-30 Amp.	31-60 Amp.	60-100 Amp.
D. P. M. L.	$0.27	$0.70	$1.75
T. P. M. L.	.40	1.00	2.30
D. P. S. B.	.35	.87	.....
T. P. S. B.	.67	1.50	.....
D. P. D. B.	.65	1.75	.....
T. P. D. B.	1.12	3.00	.....
T. P. to D. P. D. B.	.75	2.10	.....

FLEXIBLE CORD—Price per 1,000 ft. in coils of 250 ft.:

No. 18 cotton reinforced heavy		$18.50
No. 16 cotton reinforced heavy		23.50
No. 18 cotton reinforced light		16.00
No. 16 cotton reinforced light		20.50
No. 18 cotton Canvasite cord		15.50
No. 16 cotton Canvasite cord		19.00
No. 16 super service cord or similar (2 wire) in 1,000 ft	$92.00	*101.20
No. 14 super service cord or similar (2 wire) in 1,000 ft	133.00	*146.40

*Less than 1,000 ft.

NATIONAL ELECTRIC CODE FUSES, NON-REFILLABLE—

250-Volt	Std. Pkg.	List	600-Volt	Std. Pkg.	List
3-amp. to 30-amp.	100	$0.15	3-amp. to 30-amp.	100	$0.30
35-amp. to 60-amp.	100	.30	35-amp. to 60-amp.	100	.60
61-amp. to 100 amp.	50	.90	65-amp. to 100-amp.	50	1.50
101-amp. to 200-amp.	25	2.00	110-amp. to 200-amp.	25	2.50
201-amp. to 400-amp.	25	3.60	225-amp. to 400-amp.	25	5.50
401-amp. to 600-amp.	10	5.50	450-amp. to 600-amp.	10	8.00

Discount: Less 1-5th standard package, 60%; 1-5th to standard package, 64%; standard package, 68%.

RENEWABLE FUSES—List price each:

Sizes	250-Volt List-Price	600-Volt List-Price	Std. Pkg. Quantity	Carton Quantity
1 to 30-amp.	$0.50	$1.10	100	10
35 to 60-amp.	1.00	1.25	100	10
65 to 100-amp.	2.00	3.00	50	5
110 to 200-amp.	4.00	5.00	25	5
225 to 400-amp.	7.50	11.00	25	1
450 to 600-amp.	11.00	16.00	10	1

REFILLS—

1 to 30-amp.	$0.03 ea.	$0.05	100	100
35 to 60-amp.	.05 ea.	.06	100	100
65 to 100-amp.	.10 ea.	.10	50	50
110 to 200-amp.	.15 ea.	.15	25	50
225 to 400-amp.	.30 ea.	.30	25	25
450 to 600-amp.	.60 ea.	.60	10	10

Discount Without Contract—Fuses:	
Broken carton	5%
Unbroken carton but less than std. pkg.	22%
Std. pkg.	40%
Discount Without Contract—Renewals:	
Less than std. pkg.	Net list
Standard package	40%
Discount With Contract—Fuses:	
Broken cartons	10%
Unbroken cartons but less than standard package	26%
Standard package	42%
Discount With Contract—Renewals:	
Less standard package	Net list
Standard package	42%

FUSE PLUGS, MICA CAP—

0-30 ampere, standard package (500)	$2.75
0-30 ampere, less than standard package	3.00

LAMPS—Below are present quotations in less than standard package quantities on Mazda standard A type bulbs:

100—130 Volt Watts	Type	Price Each	200—260 Volt Watts	Type	Price Each
15	A 17	$0.25	Special		
General			25	A 19	$0.30
25	A 19	.25	50	A 21	.30
40	A 21	.25	100	A 23	.53
50	A 21	.27			
60	A 21	.30			
100	A 23	.43			

Standard pkg. quantities are subject to discount of 10% from list. Annual contracts ranging from $75 to $300,000 net allow a discount of 15 to 40% from list.

PLUGS, ATTACHMENT—

	Each
Porcelain separable attachment plug	$0.18
Composition 2-piece attachment plug	.27
Swivel attachment plug	.12
Small size—2 Pc. Plug—Composition	.07

RUBBER-COVERED COPPER WIRE—Per 1000 ft. f. o. b. New York:

No.	Solid Single Braid	Solid Double Braid	Stranded, Double Braid	Solid Duplex
14	$6.00	$9.10	$10.90	$17.40
12	9.90	12.60	14.60	23.80
10	13.20	16.40	18.60	30.50
8	19.00	22.30	24.20	42.40
6	.....	.....	34.40	.....
4	.....	.....	48.00	.....
2	.....	.....	68.75	.....
1	.....	.....	94.70	.....
0	.....	.....	115.00	.....
00	.....	.....	138.00	.....
000	.....	.....	165.00	.....
0000	.....	.....	196.00	.....

SOCKETS, BRASS SHELL—Price each, net:

	½ In. or Pendant Cap— Key	Keyless	Pull	¾ In. Cap— Key	Keyless	Pull
Standard package.	$0.17	$0.15	$0.22	$0.20	$0.18	$0.25
Unbroken carton	.18	.16	.23	.22	.19	.26
Broken carton	.20	.18	.25	.24	.21	.28

WIRING SUPPLIES—

Friction tape, ¾ in., less 100 lb. 33c. lb.; 100 lb. lots	31c. lb.
Rubber tape, ¾ in., less 100 lb. 35c. lb.; 100 lb. lots	33c. lb.
Wire solder, less 100 lb. 33c. lb., 100 lb. lots	31c. lb.
Soldering paste, 2 oz. cans	$1.00 doz.

ENCLOSED SWITCHES, KNIFE—Safety type, externally operated, 250 d.c or a.c., N.E.C.

TYPE "C" FUSED BOTTOM

Size, Amp.	Double Pole, Each	Three Pole, Each	Four Pole Each
30	$4.50	$6.00	$7.25
50	7.50	8.25	10.50
100	10.50	13.00	22.50
200	16.00	20.00	36.00

Discounts:	
Less than $25.00 list value	30%
$25.00 to $50.00 list value	30-5%
$50.00 list value or over	35%